AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

ANNUAL REPORT

OF THE

BOARD OF CONTROL

FOR THE

FISCAL YEAR ENDING JUNE 30, 1912

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

CARSON CITY, NEVADA
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
1913

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AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Annual Report of the Board of Control The Director and the Members of the Station Staff

For the

Fiscal Year Ending June 30, 1912

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

General

THE AGRICULTURAL EXPERIMENT STATION

THE BOARD OF CONTROL

STAFF

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MILES BRYCE KENNEDY, B.S....Assistant in Food and Drug Inspection
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ELLSWORTH RICHARD BENNETT, B.S.[3]....Deputy Sealer of Weights and Measures
CHARLES L. BROWN, B.A....In Charge Eelworm Investigations
THEODORE W. CLARK....Superintendent of Farm
MRS. T. W. COWGILL, M.A....Librarian
LOUISE BLANEY....Clerk

[1] Resigned, January, 1912. [2] On leave of absence. [3] Resigned, March, 1912.

LETTERS OF TRANSMITTAL

UNIVERSITY OF NEVADA,
UNITED STATES AGRICULTURAL EXPERIMENT STATION,
RENO, December 1, 1912.

To ROBERT LEWERS, *Acting President, University of Nevada.*

SIR: In accordance with the Act of Congress approved March 2, 1887, establishing and regulating experiment stations, and the Act of Congress approved March 16, 1906, known as the Adams Act, I have the honor herewith to submit the report of the United States Agricultural Experiment Station of the University of Nevada, for the fiscal year ending June 30, 1912.

GORDON H. TRUE,
Director.

UNIVERSITY OF NEVADA, December 1, 1912.

To the Honorable, The Board of Control of the United States Agricultural Experiment Station.

SIRS: I have the honor to transmit herewith the annual report of the Director of the University of Nevada Agricultural Experiment Station, for the fiscal year ending June 30, 1912.

ROBERT LEWERS,
Acting President.

REPORT OF BOARD OF CONTROL

OFFICE OF THE BOARD OF CONTROL,
RENO, NEVADA, December 31, 1912.

To His Excellency, TASKER L. ODDIE, *Governor of Nevada.*

SIR: We, the Board of Control of the Nevada Agricultural Experiment Station, under the Act of February 8, 1889, submit herewith our report for the fiscal year ending June 30, 1912.

At the Twenty-fifth Session of the State Legislature of Nevada, held in 1911, the Experiment Station received an appropriation for its support for two years of $3,000, and an appropriation for the carrying on of the work of the Mount Rose Observatory of $2,000.

The live stock belonging to the Experiment Station was transferred to the Agricultural College of the University of Nevada for $5,000, which amount was appropriated by the State for this purpose.

Under the Hatch Act the Station receives from the Federal Government $15,000 annually, which amount is devoted to general work in agriculture, maintenance of the Experiment Farm, and the publishing of the results of the experiments and research by the various members of the Station Staff.

Under what is known as the Adams Act the Station also receives from the Federal Government the sum of $15,000 annually which must be devoted to original research and investigation in agriculture and kindred subjects by the various members of the Station Staff.

We publish herewith the report of the Director, including the financial report of the Station, and the reports of the different departments of the Station.

You are respectfully referred to the accompanying reports for exact information upon the subjects treated.

Respectfully submitted,

A. A. CODD, *Chairman,*
FRANK WILLIAMS,
CHAS. B. HENDERSON,
HOSEA E. REID,
JAMES W. O'BRIEN,
Board of Control.

REPORT OF THE STATION STAFF

REPORT OF THE DIRECTOR

RENO, NEVADA, December 1, 1912.

To the Honorable, The Board of Control of the Nevada Agricultural Experiment Station.

SIRS: Herewith I submit my annual report for the fiscal year ending June 30, 1912, together with departmental reports of the United States Agricultural Experiment Station of the University of Nevada. My report includes the main administrative details, the financial report, and the needs of the Station.

ADMINISTRATION

The number of persons in the staff who are giving expert services in conducting experiments and investigations is eleven; the staff is divided among the following departments, Botany, Horticulture and Forestry; Agriculture and Animal Husbandry; Entomology; Chemistry; Veterinary Science and Bacteriology; Meteorology and Climatology; Department of Food and Drug Control; Department of Weights and Measures; and Library.

A few changes have occurred in the staff during the year.

Gordon H. True, connected with the Station since 1903 as Professor of Agriculture and Animal Husbandry, by action of the Board of Control, April 3, 1912, was elected Director of the Station, vice Joseph E. Stubbs, resigned.

Chas. S. Knight, who began work in the Station in 1909, as Agronomist, resigned on January 1, 1912. to become chief agriculturist for the Nevada Sugar Company at Fallon, Nevada.

With the approval of the Office of Experiment Stations, May, 1912, Mr. Chas. L. Brown was put in charge of field work in connection with the investigation of the eelworm problem in this State, the work having been approved as an Adams Fund project.

Mr. Ellsworth R. Bennett, Deputy Sealer of Weights and Measures, resigned in March, 1912.

Mr. Silas E. Ross was appointed Deputy Sealer of Weights and Measures, March, 1912, vice Ellsworth R. Bennett, resigned.

ABSENCES

Dr. C. A. Jacobson, Chemist, is still absent on leave and is working in foreign laboratories.

AIM

The primary object of the Station is the promotion of agriculture along scientific lines by conducting researches on the physiology of plants and animals; the diseases to which they are subject, with remedies for the same; the chemical composition of useful plants at different stages of growth; crop rotation; acclimatization of trees and plants; analysis of soils and waters; chemical composition of manures and fer-

tilizers, with experiments to test their effects on crops; the composition and digestibility of foods for domestic animals; the production of beef, mutton, pork, milk, butter, and cheese, through improved strains and intelligent feeding; the proper use of water in irrigation; the reclamation of alkali lands and the prevention of the rise of alkali; the economic relation of entomology to agriculture; the relation of climate to agriculture and horticulture; the conservation of snow; the forecasting of frost; the determination of relatively frost-free areas for fruit growing; in fact, the solving of all problems pertaining to agriculture which are or may be of importance to the State.

The results of the work of the Station are made public through bulletins and reports, which are sent free to all residents of the State who desire them.

INSPECTIONS

The inspection of food and drugs by Act of the Legislature, 1909, is intrusted to the Station through its Director, who is responsible for the execution of the public laws relating to these matters. The Nevada State Legislature passed an Act fixing the standard weights and measures and regulating the sale of articles of merchandise according to such standards, and the Act was approved by the Governor, March 8, 1911. By this Act the supervision and enforcement of the law concerning standard weights and measures is placed in the hands of the Director of the Experiment Station, who is designated and constituted ex officio Sealer of Weights and Measures and is charged with the proper enforcement of this Act. He may appoint such deputy or deputies as he deems necessary.

The reports of the Departments of Food and Drugs Control, and Weights and Measures are issued as separate reports.

MAINTENANCE FUNDS

State

The legislative appropriations granted for the maintenance of the Station for the biennial term beginning 1911 were as follows:

For support of Experiment Station	$3,000.00
For support of Mt. Rose Observatory, Department of Meteorology and Climatology	$2,000.00
By transfer of live stock from the Experiment Station to the College of Agriculture in the University	$5,000.00

Federal

Hatch Fund

To receipts from the Treasurer of the United States as per appropriations for fiscal year ended June 30, 1912, under Act of Congress approved March 2, 1887	$15,000.00

Adams Fund

To receipts from the Treasurer of the United States as per appropriations for fiscal year ended June 30, 1912, under Act of Congress approved March 16, 1906	$15,000.00

STATION PUBLICATIONS

The publications of the Station consist of bulletins which present in detail the method and data of the experiments and investigations conducted; technical bulletins which are technically scientific; the annual report of the Station, the reports of the Food and Drugs and Weights and Measures Departments, and circulars.

The following bulletins have been published and credited to this year:

1. Technical Bulletin No. 78, dated September, 1911. Subject: *Concerning the Relation of Food to Reproductive Activity and Longevity in Certain Hymenopterous Parasites* (first paper), by Samuel B. Doten, Entomologist.

2. Bulletin No. 79, dated January, 1912. Subject: *The Avoidance and Prevention of Frost in the Fruit Belts of Nevada,* by J. E. Church, Jr., Meteorologist, and S. P. Fergusson, Associate Meteorologist.

3. Circular No. 1, of the Department of Weights and Measures, dated March, 1912. Subject: *Tolerance on Bread.*

4. Circular No. 5, of the Department of Weights and Measures, dated March, 1912. Subject: *Tolerance on Butter.*

5. Circular No. 6, of the Department of Food and Drugs Control, dated March, 1912. Subject: *Saccharin in Food.* This circular replaces No. 12, dated May, 1911, of this department, withdrawn.

6. Annual report of the Board of Control for the year ending June 30, 1911.

7. *Intracellular Bodies Associated with Equine Anemia,* by Winfred B. Mack, D.V.M. A reprint from the Proceedings of the American Veterinary Medical Association, August, 1911.

These publications are free to all citizens of the State who ask for them.

NEEDS OF THE STATION

In order to meet the rapidly increasing demands that farmers are making upon all the public agencies established for their benefit, agricultural colleges and experiment stations must develop their equipment in proportion to the work they are called upon to do. Farm practice is more and more insistently asking that science solve its problems and direct its methods, and this Station has now certain well-recognized needs which should be met if it is to keep pace with its opportunities for service. These are in part: Extension and demonstration work; cooperative experiments; the forming of seed-testing associations; soil survey of the State; dairy survey; orchard survey; and the eradication of insect and other pests, as the potato eelworm, and the prevention of alfalfa weevil. So varied are the agricultural interests, and so numerous the problems the Station should deal with, that it is for the purpose of enlarging these phases of its activities that we are asking the Legislature, through our Board of Control, to add to its maintenance funds.

FINANCIAL STATEMENT

University of Nevada

NEVADA AGRICULTURAL EXPERIMENT STATION

In account with

THE UNITED STATES APPROPRIATIONS, 1911–1912

Items	Abstract	Hatch Fund	Adams Fund
Debtor			
To balance from appropriations for 1910–1911		$883.24	$1,035.18
Receipts from the Treasurer of the United States as per appropriations for fiscal year ended June 30, 1912, under Acts of Congress approved March 2, 1887 (Hatch Fund) and March 16, 1906 (Adams Fund)		14,116.76	13,964.82
		$15,000.00	$15,000.00
Creditor			
By salaries	1	$7,476.88	$12,351.31
By labor	2	5,174.30	155.50
By publications	3	322.59	
By postage and stationery	4	125.10	67.02
By freight and express	5	43.99	172.57
By heat, light, water, and power	6	21.65	85.50
By chemicals and laboratory supplies	7	140.77	65.61
By seeds, plants, and sundry supplies	8	249.30	576.65
By fertilizers	9	0.00	0.00
By feeding stuffs	10	929.72	210.00
By library	11	4.80	69.76
By tools, machinery, and appliances	12	66.25	200.10
By furniture and fixtures	13	17.55	68.50
By scientific apparatus and specimens	14	32.05	435.39
By live stock	15		110.00
By traveling expenses	16	322.05	402.79
By contingent expenses	17	73.00	14.75
By buildings and land	18		14.55
Totals		$15,000.00	$15,000.00

ABSTRACT 1—SALARIES

Items	Hatch Fund	Adams Fund
a. Director and other administrative officers and clerks	$3,610.20	
b. Scientific staff	2,366.68	$11,083.31
c. Assistants to scientific staff	1,500.00	1,268.00
d. Special and temporary services		
Totals	$7,476.88	$12,351.31

ABSTRACT 2—LABOR

a. Annual and monthly employees	$4,004.60	
b. Daily employees	1,169.70	$155.50
c. Hourly employees		
Totals	$5,174.30	$155.50

ABSTRACT 3—PUBLICATIONS

a. For printing 2 bulletins—Number of pages 42; total edition 2,500	$273.09	
b. For printing annual report		
c. For envelopes for bulletins and reports	49.50	
d. Other expenses		
Totals	$322.59	

ABSTRACT 4—POSTAGE AND STATIONERY

a. Postage	$61.50	$10.93
b. Stationery	56.10	56.09
c. Telegraph and telephone	7.50	
Totals	$125.10	$67.02

ABSTRACT 5—FREIGHT AND EXPRESS

Items	Hatch Fund	Adams Fund
Freight and express	$43.99	$172.57
Totals	$43.99	$172.57

ABSTRACT 6—HEAT, LIGHT, WATER AND POWER

a. Heat	$8.60	$35.70
b. Light	1.95	
c. Water	11.10	
d. Power		49.80
Totals	$21.65	$85.50

ABSTRACT 7—CHEMICAL AND LABORATORY SUPPLIES

a. Chemicals		$31.37
b. Other supplies	$140.77	34.24
Totals	$140.77	$65.61

ABSTRACT 8—SEEDS, PLANTS AND SUNDRY SUPPLIES

a. Agricultural	$35.25	
b. Horticultural	53.75	
c. Botanical	137.70	$59.52
d. Entomological	19.25	73.40
e. Veterinary science		6.75
f. Meteorological		437.00
g. Miscellaneous	3.35	
Totals	$249.30	$576.67

ABSTRACT 9—FERTILIZERS

a. Fertilizers	$0.00	$0.00

ABSTRACT 10—FEEDING STUFFS

a. Feed of horses under experiment		$210.00
b. Purchase of feeding stuffs	$929.72	
Totals	$929.72	$210.00

ABSTRACT 11—LIBRARY

a. Small purchases	$4.80	$69.76
Totals	$4.80	$69.76

ABSTRACT 12—TOOLS, MACHINERY AND APPLIANCES

a. New purchases	$61.50	$200.10
b. Repairs	4.75	
Totals	$66.25	$200.10

ABSTRACT 13—FURNITURE AND FIXTURES

a. Desk, lockers, etc.		$68.50
b. Sundries	$17.55	
Totals	$17.55	$68.50

ABSTRACT 14—SCIENTIFIC APPARATUS AND SPECIMENS

Items	Hatch Fund	Adams Fund
Thermometer		$23.35
Apparatus (consolidated)		113.38
Watch		5.00
Camera		135.00
Microscope		131.60
Sundries		27.06
Scales	$21.00	
Frost alarm	10.00	
Miscellaneous	1.05	
Totals	$32.05	$435.39

ABSTRACT 15—LIVE STOCK

Horses		$110.00
Total		$110.00

ABSTRACT 16—TRAVELING EXPENSES

a. In supervision of Station work	$20.40	
b. In connection with investigations under Adams Act		$402.79
c. For other purposes connected with Station work	301.65	
Totals	$322.05	$402.79

ABSTRACT 17—CONTINGENT EXPENSES

Storage on motor boat at Tahoe		$14.75
Dues in Association of American Agricultural Colleges and Experiment Stations for 1911-1912	$25.00	
Auditors	30.00	
Insurance	18.00	
Totals	$73.00	$14.75

ABSTRACT 18—BUILDINGS AND LAND

Rental of house, Mt. Rose, meteorology		$14.55
Total		$14.55

SUPPLEMENTARY STATEMENT

Items	State appropriations	Fees	Farm products	Miscellaneous	Totals
Debtor					
To balance on hand			$788.82		$788.82
To receipts from other sources than the United States	$5,000.00		$8,147.42		$13,147.42
Totals	$5,000.00		$8,936.24		$13,936.24
Creditor					
By salaries			$1,610.78		$1,610.78
By labor	$53.50		1,119.00		1,172.50
By publications	635.35		874.17		1,509.52
By postage and stationery	20.80		8.70		29.50
By freight and express	80.88		183.14		264.02
By heat, light, water and power	37.90		265.25		303.15
By chemicals and laboratory supplies			16.76		16.76
By seeds, plants and sundry supplies	207.10		343.27		550.37
By fertilizers					0.00
By feeding stuffs	178.60		1,709.01		1,887.61
By library			5.31		5.31
By tools, machinery and appliances	259.70		292.20		551.90
By furniture and fixtures	381.10				381.10
By scientific apparatus and specimens			12.90		12.90
By live stock	201.00		949.00		1,150.00
By traveling expenses	101.70		897.98		999.68
By contingent expenses			368.25		368.25
By buildings and land	462.50		134.80		597.30
By balance	2,379.87		145.72		2,525.59
Totals	$5,000.00		$8,936.24		$13,936.24

All expenditures are supported by vouchers approved by the Finance Committee of the Board of Control and are on file in the office of the Comptroller.

DEPARTMENTAL REPORTS

The reports of the several departments of the Station are herewith given. Each gives a complete account of the work done by the department under the Hatch and Adams Funds. These departments are as follows:

1. Department of Agriculture and Animal Husbandry.
2. Department of Botany, Horticulture and Forestry.
3. Department of Chemistry.
4. Department of Entomology.
5. Department of Meteorology and Climatology.
6. Department of Veterinary Science and Bacteriology.
7. Department of Library.

The reports of the Department of Food and Drugs Control and of the Department of Weights and Measures are published separately.

I have the honor to remain,

Yours very truly, GORDON H. TRUE,
Director.

REPORT OF
DEPARTMENT OF AGRICULTURE AND ANIMAL HUSBANDRY

GORDON H. TRUE,
[1]CHAS. S. KNIGHT,
FRANK L. PETERSON.

IRRIGATION EXPERIMENTS

The irrigation experiments in the grain crops of White Australian wheat and Siberian oats were continued on the same schedule as in the preceding three years. Two acres, containing eight one-fifth-acre plats and two one-tenth-acre plats, are devoted to each crop. The object of the experiment is to show the relation of the time of irrigation water to the composition and the yield of the grain. The schedule of irrigations vary from three irrigations before and two after heading (maximum application) to one before and one after heading (minimum application). The one-fifth-acre plats are diked and irrigated by the flooding system. Measurements of water applied are made by means of a Cippoletti weir.

White Australian Wheat

Area in acres	Irrigations: Before heading	Irrigations: After heading	Applied depth in feet	Yield per acre	Yield in pounds	Yield per acre-foot water in bushels
One-fifth	3	2	2.138	33.3	3,370	15.57
One-fifth	3	1	1.171	31.3	3,375	26.73
One-fifth	2	3	2.138	43.3	4,205	20.26
One-fifth	2	2	1.448	45.1	3,820	31.29
One-fifth	2	1	1.276	43.8	3,970	34.33
One-fifth	1	3	1.690	49.1	4,330	29.06
One-fifth	1	2	1.345	51.3	4,820	38.14
One-fifth	1	1	1.103	32.4	2,930	36.98

Siberian Oats

Area in acres	Irrigations: Before heading	Irrigations: After heading	Applied depth in feet	Yield per acre	Yield in pounds	Yield per acre-foot water in bushels
One-fifth	3	2	1.530	50.0	2,800	32.68
One-fifth	3	1	1.483	52.7	2,365	36.37
One-fifth	2	3	1.798	58.6	3,000	32.68
One-fifth	2	2	1.414	53.8	2,705	38.15
One-fifth	2	1	.966	57.2	2,445	59.21
One-fifth	1	3	1.483	59.1	2,835	39.96
One-fifth	1	2	1.241	54.1	2,770	43.59
One-fifth	1	1	.793	38.8	1,985	48.92

Cooperative Work With Irrigation Investigations, U. S. Department of Agriculture

The additional work in the soil-tank series as outlined in the 1911 report was taken up. In March a new series of tanks were installed concentric with the old installation. The tanks were filled with soil, subirrigators installed at a depth of thirteen inches and the equipment was allowed to remain undisturbed in order that soil conditions in the tanks

[1]Resigned January 1, 1912.

might become uniform. In April, Tanks 9, 10, 11, 12, 13, and 14 were planted to a club wheat. It was designed to give Tanks 9 and 10 the minimum quantity of water possible and still have the plants grow; Tanks 11 and 12 were to have close to one foot of irrigation, and Tanks 13 and 14 were to be kept at a constant percentage of moisture by having the water lost in the previous three-day period replaced after weighing. This experiment is making very excellent progress. The object of the study is to determine if possible the amount of water required by wheat at the different stages of growth, and the number of pounds of water required to produce a pound of wheat under the climatic and soil conditions at Reno, Nevada.

The study of the number of pounds of water required to produce a pound of alfalfa hay were continued from last season and is making very interesting progress.

It is planned to extend the soil-tank studies in crops to the sugar beet, potatoes, barley and oats.

Irrigation of Alfalfa

The acre plots of alfalfa used in irrigation experiments in which the flooding and furrow methods have been compared during the past two years were used in continuation of the observations this year. The results are given in the table below.

Plots 20 to 23, inclusive, are 650 feet in length and have a fall of about one foot to the hundred, while the fall in Plots 24 and 25 is about the same. They are but 250 feet long and the greater amount of water used may be accounted for by more excessive waste due to the shorter rows.

Alfalfa

Plot	Area	Depth of water in feet	Date of cutting	Yield per acre	
				Pounds	Tons
20	1 acre—Flooded	3.636	July 5—First	4,337	
			Aug. 18—Second	3,855	
			Oct. 9—Third	2,111	
				10,303	5.15
21	1 acre—Flooded	2.656	July 5—First	4,315	
			Aug. 18—Second	4,065	
			Oct. 9—Third	2,235	
				10,615	5.31
22	1 acre—Furrowed	2.246	July 5—First	3,930	
			Aug. 18—Second	3,600	
			Oct. 9—Third	1,591	
				9,121	4.56
23	1 acre—Furrowed	2.165	July 5—First	3,720	
			Aug. 18—Second	3,330	
			Oct. 9—Third	1,485	
				8,535	4.27
24	1 acre	3.867	July 5—First	3,570	
			Aug. 18—Second	3,105	
				6,675	3.34
25	1 acre	3.867	July 5—First	3,230	
			Aug. 19—Second	3,060	
				6,290	3.15

Corn for Silage

During the spring of 1911 northern Wisconsin- and Minnesota-grown varieties of field corn were secured with the idea of testing their value for silage. All varieties were planted on May 28 and were caught by frost on August 31 before ears had formed. The following table gives the yield of fodder at the time of cutting on August 31:

RESULTS WITH CORN FOR SILAGE, 1911

Variety	*Yield per acre* *Pounds*	*Tons*
Golden Glow	35,270	17.6
Squaw Field Corn	44,704	22.4
Yellow Field Corn	44,220	22.1
Smut Nose Corn	30,272	15.1

Results With Spring Grains

Variety	Date of seeding	Date of heading	Amount sown per acre	Date of harvest	Yield	Yield per acre
Swedish Select oats	April 15	July 5	64 lbs.	Aug. 7	66	60.27
White Australian wheat	April 15	July 5	75 lbs.	Aug. 15	98½	48.21
Beardless barley	April 15	June 20	90 lbs.	July 20	102	62.10
Sixty-day oats	April 15	June 24	64 lbs.	Aug. 1	75	68.48
Kubanka wheat	April 15	June 30	75 lbs.	Aug. 12	96	46.75
Siberian oats	April 15	July 5	64 lbs.	Aug. 7	61	55.70
Oderbrucker barley	April 15	June 22	90 lbs.	July 25	104	63.31

Variety Tests of Spring Grains

Variety	Date of irrigations	Date of seeding	Date of heading	Date of harvest	Yield in pounds	Yield per acre
Beardless barley	May 8 June 16 June 26	April 8	June 20	July 19	Grain 654 Straw 546	40.88 bus. 1,638 lbs.
Spring rye	May 8 June 10 June 26 July 5	April 8	June 20	Aug. 1	Grain 442 Straw 813	23.70 bus. 2,439 lbs.
Swedish select oats	May 8 June 10 June 26 July 5	April 12	June 30	Aug. 5	Grain 695 Straw 1,065	65.16 bus. 3,195 lbs.

Variety Tests of Winter Grains

Variety	Amount sown per acre, lbs.	Date of seeding	Date of irrigations	Date of harvest	Yield in pounds	Yield per acre
Rye No. 13	75	Oct. 26	May 22	July 14	68	32.64
Wheat 1559	75	Oct. 26	June 13	July 20	111	49.67
Wheat 1564	75	Oct. 26	June 28	July 20	100	44.75
Wheat 1571	75	Oct. 26		July 20	100	
Wheat 1656	75	Oct. 26		July 20	92	41.17
White Australian wheat	75	Oct. 26		July 22	65	29.59
Einkorn	10[a]	Oct. 27		July 22	77	43.07
Tennessee Winter barley	100	Oct. 27		July 8	62	34.68
Emmer	9[a]	Oct. 27		July 25	100	83.91
Spelt	7½[a]	Oct. 27		July 22	107	59.86
Rye No. 1	75	Oct. 27		July 14	69	33.12
Kubanka wheat	75	Nov. 3		July 25		
Wheat 1571	75	Nov. 3		July 20	476	42.13

[a]Seeded.

Potatoes

Variety	Date of seeding	Date of irrigation	Number of rows	Length of rows	Yield per acre in bushels
Blue Victor	May 19	June 8 June 22	4	165 feet	177.5
Early Red	May 19	July 7 July 24	4	165 feet	161.2
Peerless	May 19	Aug. 2 Aug. 12	4	165 feet	243.3
Peachblow	May 19	Aug. 22 Sept. 7	4	165 feet	110.3
Burbank	May 19		4	165 feet	228.5
Dalmeny Challenge	May 19		4	165 feet	269.3

SUGAR BEET INVESTIGATIONS

(In cooperation with Office of Sugar Plant Investigations, U. S. Department of Agriculture.)

In these experiments the beet seed was sown about April 20, 1911, on a well-prepared seed bed. Following the seeding was a short period of warm weather which started the germination of the seed. During the first part of May a cold, wet spell set in and lasted about two weeks. This proved disastrous to many of the small tender plants, and when the crop appeared above the ground it was thought advisable to plow under the few beets present and plant the ground to some other crop. After a more careful examination, however, the stand of beets, although very poor, was found to be quite uniform on all of the plats, so it was decided to continue the investigations with the beets, since the comparison was the principal factor desired. This accounts for the small yields of beets on most of the plats. The following table gives the results of investigations on the cultural methods for sugar beets:

Results of Sugar-Beet Investigations, 1911

Cultivation[1]

Plat number	Time of seeding	Rate of seeding—Pounds	Width of rows—Inches	Distance of plants in rows—Inches	Average yield per acre—Tons	Per cent sugar in juice	Per cent sugar in beet	Purity, per cent
1	Apr. 20	15	20	8	5.41	21.7	20.7	96.3
2	Apr. 20	15	20	8	7.51	21.4	19.3	92.3
3	Apr. 20	15	20	8	4.94	21.0	20.0	91.5
4	Apr. 20	15	20	8	8.04	21.3	20.2	93.0

[1] Plat 1—One cultivation after each irrigation. Plat 2—Average number at usual times. Plat 3—Crowd six cultivations into ordinary period. Plat 4—Extend period if practicable, operating at about usual intervals.

Rate of Seeding

1	Apr. 20	15	20	8	7.69	20.6	19.6	91.3
2	Apr. 20	20	20	8	8.23	21.4	21.5	93.2
3	Apr. 20	25	20	8	8.80	22.4	21.3	95.5
4	Apr. 20	30	20	8	8.34	21.3	20.3	91.1

Width of Rows—Plants 6 inches apart in rows

1	Apr. 20	15	16	6	9.53	22.7	21.5	93.9
2	Apr. 20	15	18	6	9.32	21.5	20.4	95.8
3	Apr. 20	15	20	6	7.10	21.3	20.8	95.2
4	Apr. 20	15	24	6	7.77	21.1	20.0	92.6
5	Apr. 20	15	20	8	8.47	21.4	20.2	93.0

Width of Rows—Plants 8 inches apart in rows

1	Apr. 21	15	16	8	10.92	21.2	20.2	94.1
2	Apr. 21	15	18	8	7.75	22.8	21.7	94.6
3	Apr. 21	15	20	8	8.88	21.8	20.7	95.4
4	Apr. 21	15	24	8	6.35	20.9	19.9	92.0

Width of Rows—Plants 12 inches apart in rows

1	Apr. 21	15	16	12	7.98	22.4	21.3	93.2
2	Apr. 21	15	18	12	6.20	22.3	21.2	94.0
8	Apr. 21	15	20	12	6.67	22.0	20.9	95.7
4	Apr. 21	15	24	12	6.28	21.7	20.6	95.2
5	Apr. 21	15	20	8	8.61	22.2	21.1	94.3

ANIMAL HUSBANDRY

The Department of Animal Husbandry has been developed largely with a view to the part that it should have in the work of the Agricultural College. It has been the aim in building up for this department to do so along lines that would make the equipment most useful as an adjunct or part of the Agricultural College equipment. The fact that the Agricultural College proper has had no college farm and no facilities for caring for stock seemed to make it necessary to start this work in the station and later turn it over to the college. By Act of the last Legislature an appropriation of $5,000 was given the University for the purchase of the live stock owned by the Experiment Station. The transfer was not made on the books of the institution until the end of the year for which this report is made. This department has continued to use the State Fair grounds for the care and housing of the animals, paying an annual rental fee of $450 to the State Board of Agriculture.

During the year, Jersey cattle have been added to the equipment by the purchase of a bull calf from the N. H. Locke Company, Lockeford, Cal., and two heifers from George Smith, Corcoran, Cal. Four head of Aberdeen-Angus cattle, a bull and three heifers, were purchased at the International sale. Two of the four stood third in their respective classes at the 1911 International show.

The Hereford herd, started by the gift of a pair of young cattle by Mr. J. H. Cazier of Wells, has been increased during the year by the sale of one of these and the reinvestment of the proceeds in a cow and three young heifers from the same herd.

The department has also received further gifts—a young Hereford bull and two steers—from Mr. Cazier.

A ram and three ewes of the Rambouillet breed were purchased from the Illinois Agricultural College, adding one more to the number of pure breeds kept by the University.

The raising of winter lambs for the San Francisco market has been discontinued on account of the failure of San Francisco as a market for this product. Only by offering lambs year after year was it possible to determine the actual demand. Since lambs were first offered by the Station, when the Palace Hotel management offered 40 cents a pound for winter lambs, the methods of hotel management in the coast city seem to have changed until no high-priced meat is bought even by the best hotels and restaurants. The result is that the past season there was no sale in San Francisco for winter lambs at prices save the market price of spring lambs.

The Station has been able to produce winter lambs ready for market as from Christmas to Easter at a cost of about $3.50 a head, charging against the lamb all the cost of feed of the ewes during the time of suckling the lamb. We have found the grade Dorset ewes from Merino dams the best of mothers, and they produce fall lambs more freely even than the pure-bred Dorset ewes.

EXHIBITS

The record exhibit of live stock was made at the California State Fair last September. The winnings amounted to something over $700 in cash, the exhibits being awarded, 12 championship medals, 32 first prizes, 18 seconds, and 10 thirds, and a special prize for the best exhibit of live stock by an educational institution. This last was in competition with the University of California and the California Polytechnic School at San Luis Obispo.

It is planned that in the future experimentation work of the Station with live stock the college stock shall be used and the Station shall bear the expense of the work during the experiments.

REPORT OF
DEPARTMENT OF BOTANY, HORTICULTURE AND FORESTRY

P. B. Kennedy
A. A. Heller

From October 1, 1910, to October 1, 1911, the head of the department was on sabbatical leave from the University. The trip to England, by way of California, Oregon, Washington, and thence to Vancouver, enlarged the horizon of the writer's heretofore only reading knowledge of that vast territory in relation to its horticultural and agricultural interests. The journey across the continent, by the way of the Canadian Pacific Railway, acquainted him with that immense treeless country with its new, but substantial, agricultural settlements, and the great grass prairie still occupying hundreds of miles of territory through Alberta.

A side trip down into Ontario through well-kept and prosperous farms, brought him to the Ontario Agricultural College again, after an absence of twelve years. The gigantic strides made by this institution during the interval of a few years impressed one more than ever with the progressive character of agriculture and agricultural education. Particularly striking were the huge new buildings housing the Department of Domestic Arts and Sciences, of which twelve years previous there had not been even a suggestion. The body of men and women students met with there would compare well educationally and socially with those of any other institution engaged in educational work.

Taking the steamer from Montreal we arrived safely in England and located at Hampton within easy reach of the Royal Botanical Gardens at Kew and near London. Several months were spent at the herbarium of the Royal Botanical Gardens at Kew, studying the original specimens of the genus Trifolium collected by the early British explorers on the Pacific Coast, particularly those by Douglas about 1833. These plants are still in an excellent state of preservation. Complete notes and photographs were taken of all species that have caused more or less confusion in the botanical literature of the clovers in America.

It was interesting to note at Kew, botanists from Japan, China, Africa, as well as a number from Europe and the United States, investigating the collections from the various countries. The numerous greenhouses and well-kept grounds with everything named and classified are an inspiration to plant lovers, as well as an education to the general public who daily frequent the park by the thousands.

The Natural History museums and the numerous parks around London were visited frequently and many suggestions were laid away which we hope will be useful when the time comes to represent the flora and fauna of the State of Nevada in a natural history building on the University Campus. To the south of London there are thousands of acres of glass devoted to the raising of cut flowers for the London market, and to the north of London we visited the great truck-growing region. The kinds

of flowers and vegetables grown and the methods of marketing were carefully noted. At the meetings of the Royal Horticultural Society we were able to observe the very finest of flowers and vegetables that are grown in any part of the world.

The remainder of the time was chiefly spent in long walks through the English country, the climate, scenery and roads being of such a character as to make this pastime particularly delightful and without fatigue.

RESUME OF THE STATION ORCHARD

The Station orchard was planted out in the spring of 1903 so that the trees are now old enough to produce large quantities of apples. The climatic conditions seem to be ideal for producing an excellent vegetative growth, and the soil with the basis of clay seems to be admirably adapted for apple trees.

For the first three years after planting the young trees were badly infested with the apple aphis, or plant louse, but thorough sprayings with a decoction of tobacco stems, refuse from the cigar factory, soon relieved us of the trouble. Another season we used the kerosene emulsion with equally good results. The former, however, is much cheaper and easily prepared. We simply placed a gunnysack filled with the tobacco stems in a barrel of water and allowed it to soak for twenty-four hours or more. By diluting to about the color of black tea when diffused, it kills the aphis but not the eggs.

The fire blight, a bacterial disease, which is extremely prevalent on apple trees in town lots and in most of the orchards in the Truckee Valley, attacked a number of our trees, but prompt removal and burning of the affected limbs has prevented the spread of this disease.

Our worst enemy to contend with has been ants. They form their nests at the base of a tree and keep the soil constantly disturbed beneath the ground, so that the roots are unable to properly obtain nourishment. Though we were at first disinclined to believe that this could be the cause, the death of several trees convinced us.

Two other common insect pests in the Truckee Valley are the San José scale and the codling moth. Up to the present time the orchard seems free from the scale, with only one spraying as a preventive. No doubt its somewhat isolated location has helped to prevent the spread of the disease from other orchards. Until this year there has not been sufficient fruit for the codling moth to rear her young, but, from the abundance of wormy apples on the trees of the town lots, we should expect to have to fight this pest to a considerable extent.

Cultivation and Irrigation

During the first season 1903 the young trees were irrigated once a week, and in 1904 one acre was irrigated once a week and two acres only once a month. Those irrigated once a month seemed to do equally as well as those irrigated every week. In both cases thorough cultivation was given after each irrigation.

Cover Crops

In 1905 the following cover crops were sown in July and plowed under the following year: Canada field peas, Egyptian clover, hairy vetch, spring vetch, alsike clover, crimson clover, Mammoth red clover and white clover. Of these the hairy vetch (*Vicia villosa*) made the most growth, producing on June 27, 1906, on 12 by 12 feet, 176 pounds

of green weight, or about 26 tons to the acre. It reached a hight of 3 feet or more and kept growing until the most severe weather in January and February. Only the extreme tips of the vines showed the effects of the cold weather. Considerable difficulty was experienced in getting this tangled mass plowed under in the spring. But for this difficulty we would consider it a most excellent cover crop for this region.

Crimson clover (*Trifolium incarnatum*) did not make much growth until the following season. It was in full blossom about the middle of June and averaged about a foot in height.

Egyptian clover (*Trifolium alexandrinum*). We found this variety quite unsuited to this climate for growth as a cover crop. It made very little growth during the summer and was killed outright during the winter.

Spring vetch (*Vicia sativa*) made a fair growth, but did not withstand the winter as well as the hairy vetch.

Canadian field peas (*Pisum sativum*) suffered considerably from the hot weather and produced very little to plow under. They do very much better when sown with oats and earlier in the season, for grain feed.

Mammoth red clover (*Trifolium pratense*). This form of red clover produce very little growth until the following season, but by July 13, 1906, it thickened up considerably and a space 12 by 12 feet produced 125 pounds. This did not produce quite as much as the hairy vetch but it was much easier to plow under.

Alsike clover (*Trifolium hybridum*) and White Dutch clover (*Trifolium repens*) grew very little until the following season, a space 12 by 12 feet cut green weighing only 85 and 80 pounds respectively.

Varieties

The varieties of apple trees of bearing age now in the orchard are as follows:

American, Apple of Commerce, Arkansas Black, Bailey Sweet, Baldwin, Black Ben Davis, Ben Davis, Bietigeheimer, Chicago, Champion, Charlamof, Delicious, Duchess, Early Cotton, Early Melon, Early Harvest, Early Ripe, Fallwater, Fall Pippin, Fameuse, Golden Russet, Grimes Golden, Geneton, Gievens, Gano, Gravenstein, Gloria Mundi, Haas, Hubbardston-Jonathan, Jefferies, Keswick, Late Strawberry, Liveland Raspberry, Lawver, Limbertwig, McIntosh, Missouri Pippin, McMahon, Mammoth Black Twig, Maiden Blush, Northern Spy, N. W. Greening, Ortley, Porter, Pewaukee, Red Astrachan, Rhode Island Greening, Red June, Rambo, Roxbury Russet, Rome Beauty, Romanite, Stayman's Winesap, Scott's Winter, Senator, Stark, Springdale, Sweet Bough, Smith Cider, Summer Queen, Summer Pearmain, Twenty Ounce, Tolman's Sweet, Tompkins King, Wismer's Dessert, Waxen, White Permain, Winter Banana, White Pippin, Willow Twig, Winterstein, Wolf River, Wagener, Walbridge, Yellow Transparent, Yellow Newton, York Imperial.

Blossoming

It will readily be understood that with so many varieties the blossoming period is very irregular and of long duration. In general, late-blossoming varieties are to be preferred in this region of numerous frosts. Experience has shown us, however, that, owing to the irregularity of the frost conditions, the earlier blossoming varieties will escape while the later ones are frozen. The following began to blossom from April 24 to May 8, 1912: Winesap, McIntosh, Ortley, Smith's Cider, Early Ripe, Yellow Newton, Duchess.

Those in blossom from May 8 to 16, 1912, were as follows: Winesap, McIntosh, Golden Russet, White Pearmain, Missouri Pippin, Jonathan, Ben Davis, Grimes's Golden, Lawver, York Imperial, Pewaukee, Wagener, Beitigeheimer, Maiden's Blush, Early Harvest, Sweet Bough, Rambo, Gravenstein, Porter, Hubbardston, Delicious, Champion, Charlamof, Twenty Ounce, Early Melon, Stark, Arkansas Black, Walbridge, N. W. Greening, Gievens, Apple of Commerce, Black Ben, Rhode Island Greening, Wolf River.

The late bloomers, from May 16 to June 1, 1912, were as follows: Baldwin (sparse bloomer), Roxbury (sparse bloomer), Wealthy (barren), Northern Spy (barren), Scott's Winter (sparse bloomer), Limbertwig (sparse bloomer), Tompkins's King (barren), Geniton, Black Ben, Chicago (barren), Rome Beauty, Red Russian, Yellow Transparent, Tolman's Sweet, Duchess, Tetofski, Fameuse, Jeffries, Late Strawberry, Red Astrachan, Gano, Rambo.

The list of varieties recommended for this district, which is included in No. 14 of the American Pomological Society for commercial orchards, is as follows: Early Harvest, Red June, *Red Astrachan*, *Yellow Transparent*, *Fameuse*, *Jeffries*, *Duchess of Oldenburg*, *Gravenstein*, *Longfield*, *Maiden Blush*, *Fall Pippin*, *Wealthy*, *Alexander*, *Wolf River*, *Yellow Bellflower*, *Grimes's Golden*, *Jonathan*, *Esopus Spitzenburg*, *Delicious*, *Hubbardston*, *White Pearmain*, *McIntosh*, *Rhode Island Greening*, *Missouri Pippin*, Baldwin, *Tompkins's King*, *Wagener*, *Rome Beauty*, York Imperial, *Arkansas Black*, *Gano*, *Ben Davis*, *Stayman's Winesap*, *Winesap*, *Northern Spy*, *Yellow Newtown*.

Those italicized are said to be highly successful. We notice by the map of the districts that the whole State of Nevada is included in No. 14 with Idaho, Eastern Oregon, and Washington. The above list no doubt is based very largely on conditions in the other States, as the orchards of Nevada are very little known outside of that of Mr. Ross Lewers of Franktown, Washoe County, a decidedly unique orchard and not at all typical of the State as a whole.

We can, however, with reasonable safety recommend the following: Rome Beauty, Ben Davis, Geniton, Rambo, Gano, Early Harvest, Early Melon, and Yellow Transparent.

In addition to the above the following are well stocked with young apples this year in the Station orchard: Romanite, Charlamof, Black Ben, McMahon, Gievens, Walbridge, N. W. Greening, Wagener, Maiden's Blush and Bietigeheimer, Golden Russet, Roxbury, Grimes's Golden, Champion, Duchess.

Frost Fighting

When the orchard reached bearing age we soon found out that, although the majority of the trees had plenty of blossoms, no fruit was produced on account of severe frosts. Indeed, we could not expect a good crop of fruit even once in seven years, which is about the average for similar locations in the Truckee Valley.

In 1909 we attempted to save the crop by means of causing smudges with manure piles, but, although this will be found successful in warding off light frosts, it will not produce results where heavy freezes are encountered at the blossoming period.

In 1910 we purchased sufficient oil heaters for one acre, but were unable to maintain the necessary temperature to save the crop on

account of the character of the local oil (No. 32) used for fuel purposes. The details of this experiment are to be found on pages 21–24 in the report of 1910.

In 1911, although the writer was absent, Professor Heller secured additional heaters and attempted to save the crop on all three acres. Again, after several successful fights against the frost, a tank of oil of poor quality was delivered to us in the middle of the experiment. It was so full of water that it sputtered and burned poorly, preventing us from saving the crop when at 19 degrees. The details concerning this year are to be found in the report of the department for 1911.

The following gives the results of the work as carried on in 1912: The experimenters slept in a hut adjacent to the orchard and were awakened by means of a frost alarm. As it was a stationary one and set to ring off at 33 degrees F., one can see by looking at the table of records that we were up nearly every night in April, although only in a few instances did the temperature go low enough to make it necessary to smudge. But we could never tell. A previous experience of going down to 15 degrees suddenly from 30 degrees kept us on the anxious-seat at all times.

The following table will show that out of twenty-six days in April the thermometer in the orchard registered below freezing eighteen times. Of thirty-one days in May it only registered below freezing nine times. On May 4 the temperature reached as low as 26 degrees, but this was the only severe frost which occurred during the month.

The readings were taken from standard minimum and maximum thermometers situated in the open in the center of three acres of orchard. The maximum thermometer was facing the north and shaded from the direct sun. The reading, taken about 5 p. m., were as follows:

Temperature Readings for April

(Degrees Fahrenheit)

	Min.	*Max.*		*Min.*	*Max.*
April 5	33	67	April 18	29½	63
April 6	23	75	April 19	23	43
April 7	25	71	April 20	20	50
April 8	81	75	April 21	30	54
April 9	35	67	April 22	15[a]	65
April 10	37	54	April 23	30	71
April 11	19	47	April 24	37	58
April 12	22	53	April 25	26	60
April 13	21	75½	April 26	32	55
April 14	32½	70	April 27	23[a]	71
April 15	29	62	April 28	41	67
April 16	29	56	April 29	32	54
April 17	31½	62	April 30	31	60

[a]Smudged 3 to 5:45 a. m.

Temperature Readings for May

(Degrees Fahrenheit)

	Min.	*Max.*		*Min.*	*Max.*
May 1	32	56	May 17	34½	84
May 2	31	54	May 18	42	83
May 3	30½	62	May 19	42	62
May 4	26[a]	70	May 20	29½[b]	61
May 5	35	67	May 21	29[c]	60
May 6	37	80	May 22	37	66
May 7	30½	77	May 23	32½	76
May 8	37	73	May 24	44	68
May 9	37	79	May 25	37	60
May 10	33½	70	May 26	29	80
May 11	32	73	May 27	34½	85
May 12	31	81	May 28	37½	80
May 13	31	82	May 29	29½	78
May 14	35½	81	May 30	34	85
May 15	44	80	May 31	42	84
May 16	32½	83			

[a]Smudged 4 to 7 a. m. [b]Smudged 3 to 4 a. m. [c]Smudged 3 to 7 a. m.

The above temperatures will indicate that the number of frosts to be contended with on the Station orchard are too numerous to consider apple growing as a profitable business in the lowest parts of the Truckee Valley. The thermometer registers five degrees lower than on the University Campus, half a mile away, but situated on higher ground.

Some of the varieties began to show a slight pink to the buds as early as April 24, but the orchard, as a whole, looked extremely dormant without any leaf buds opened out. For this reason we had not begun to sleep nights in the orchard and were not calculating to begin smudging until a week or so later. But the exceedingly low temperature was reached on April 22 of 15 degrees, much lower than for any night during the preceding weeks. From examination it revealed the fact that fruit-spurs, long before the calyx-lobes open sufficiently to show the corolla, were badly frozen and damaged. The stage of the blossom in bud cannot always be relied upon, as some that were well swollen were not frozen. In the cluster of six blossoms, the normal number, a center one, usually much advanced and showing the pink red of corolla, is surrounded by five others still well protected by the calyx-lobes. In some varieties, or even in adjacent trees of the same variety, some would be frozen in the pink stage and others not. In the same way, some that were well protected by the calyx-lobes would be frozen and others not.

This low temperature did not prevent the fruit-spurs from blossoming out and appearing normal, but, although the petals were highly colored and apparently perfect, the stamens, style and ovary were reddish-brown and destroyed. The first leaves coming from the cluster were also stunted and showed the effects of the freezing.

Many of these observations are not easily explained, as trees of the same variety and at the same stage of advancement of the fruit-spur are not affected the same, even with the same conditions of soil and moisture so far as we could tell from surface conditions. One can theorize, but to get the facts is a more difficult problem.

HERBARIUM

The Station herbarium now numbers over 12,000 sheets of plants, all duly mounted and classified. It is a very necessary part of the department's equipment, as we use it as a working basis much the same as many departments use books as reference works. As each year goes by we explore and collect the plants in different and often remote mountain ranges, thus adding to the knowledge of the plant life of the State. A large amount of time is taken up in naming and classifying this material. Dr. Heller and myself have had to do most of this work in the evening, as our work of teaching in the College of Agriculture and other work in the Station fully occupy the regular hours.

As the collection is of much value to the students of the College of Agriculture, in that it contains excellent collections of grasses and forage plants, poisonous plants, and weeds, as well as shrubs and trees, we feel that at least some support should come from this source for its maintenance. The Department of Biology in the College of Arts and Sciences would like also to use the collection for class work if it were more accessible to them.

For these reasons we urgently request that financial aid be secured for us from the Agricultural College and state funds so that we may be able

to carry on this work more advantageously and relieve the Station of a portion of the expense.

We wish that the work remain under the supervision of this department at least until a flora of the State is written up. This has been our ambition for twelve years, but the State of Nevada is very large and we have had only a limited amount of time at our disposal for carrying out such a gigantic piece of work. Contrary to the general belief, the State of Nevada, owing to its great size, variation in climatic conditions and elevations, will, we earnestly believe, when thoroughly investigated, contain, at least, as many, if not more, distinct species of plants than any other State in the Union. Our only possible rival would be California.

FORESTRY INVESTIGATIONS

This work has largely been in the hands of Dr. Heller, as mentioned in last year's report. He is endeavoring to get together all the material and information relative to the native trees of Nevada and the character of the timber on the forest reserves. He has made a beginning along the line of photographs of the different species and there is on hand a large number of cones of different conifers.

This spring, with the object in view of having on hand a large number of young evergreens for windbreaks, reforestration and ornamentals, we have sown ten different species in nursery beds. From seed sown last year we now have about 2,500 Rocky Mountain yellow-pine seedlings, which will be ready to transplant next year.

PLANT DISEASES

During the writer's absence the consulting biologist, Professor Peter Frandsen, took a timely interest in a number of diseases that were causing trouble to the farmers. He is well equipped with laboratory facilities for the preparation of microscopic slides frequently necessary in the diagnosis of some of the less common diseases. In matters of this kind we have been able to cooperate most advantageously to the Station, and have saved it a large expense in the duplication of equipment for this kind of work, such as microtomes, incubators, etc.

We herewith append Professor Frandsen's report for the season of 1911:

The summer of 1911 was an unusally wet one. Probably on this account fungous diseases were more noticeable than common. Rose bushes in the vicinity of Reno suffered considerably from mildew (*Sphærotheca*). Tomatoes in the Fallon district were affected with a disease which microsopic examination of the roots proved to be fusarium wilt. In plants examined the fibrovascular bundles were packed with the mycelium of this fungus. In some gardens fully 50 per cent of the plants were attacked. What is apparently the same fungus also attacked cucumbers, squashes and watermelons, and a number of weeds; pigweeds, particularly, were killed by it. The same disease was also noted on tomatoes in Reno and vicinity, but not so extensively as at Fallon. This is the first instance of fusarium wilt being reported in this State.

We were requested to examine an orchard at Northam, Nevada, and found it extensively attacked by fire blight. Several of the apple and pear trees had been killed by it, and others were badly affected. The disease did not appear to be particularly bad in the Truckee Valley, but some instances of it were noted.

A report came from Ely, Nevada, that the Carolina poplars were dying of some obscure disease, but the specimens sent in showed nothing upon which a diagnosis could be made. In June, 1912, we were informed that the same disease was even more destructive than last year. Specimens of diseased twigs sent in showed the presence of a fungus whose nature, except that it is one of the *fungi*

imperfecti, has not yet been determined, nor is it yet certain whether it is the primary cause of the malady.

During the last two years the eelworm disease of potatoes has been prevalent in the potato-raising districts of Fallon, Yerington, Dayton, Mason, and in the Truckee Valley. On account of the interest taken by the farmers in this disease, many samples of diseased potatoes have been sent into the laboratory for examination, and among them have been noted several cases of potato scab and the disease called "internal browning."

The spring of 1912 has brought the following to our notice;

Some trees on some of the town lots of Reno showed the effects of what we believe will prove to be one of the powdery mildews, most likely a species of *podosphæra*.

The fire blight up to the present has been less harmful than usual, probably owing to the dry and rather cold season.

The only fungous disease noted in the greenhouse was the powdery mildew on the roses (*Sphærotheca*).

NURSERY

Carolina Poplars

In the spring of 1908 some large Carolina poplar trees were transplanted from the windbreak of the Station orchard to the Mackay Quadrangle. It was necessary to reduce the branches to insure vigorous growth. This gave me an opportunity to secure several thousand excellent cuttings. These were made about eight inches long and allowed to callous in a mound of soil for a month. They were planted in rows, placing each cutting about a foot apart. We have found it best to place three-fourths of the cutting below the ground, thus leaving only a small portion subjected to the heat of the sun and the drying winds. A slope of forty-five degrees seems preferable to placing them erect. Stout roots soon form and several stems form the upper buds. These are all removed but one, thus sending all the growth into a single shoot. By the following spring (1909) we had young trees from three to six feet tall which were worth 25 cents each in Reno. To make room for future growth it is necessary to thin them out to three feet apart.

The third spring (1910) the trees were of good size and bring 50 cents. By 1911 they were in ideal condition for spring street-planting and bring $1 each, wholesale.

This spring (1912) many of them were too large for safe transplanting, but they are preferred by the public and bring $1.25 up, the purchaser digging them out of the ground. We have given over to the University this spring (1912), at a nominal sum, several hundred of these trees for beautifying the grounds.

As we do not wish to grow trees when the experimental side of a problem has been demonstrated, we shall discontinue this feature of our work and leave it to private individuals and nurseries.

In like manner we have demonstrated the adaptability of several hundred shrubs not heretofore grown in this State. The results of this work we propose to place in permanent form in a bulletin. We shall, of course, continue in a small way to experiment with new or untried shrubs that might seem to us worth while adding to the list.

Fruit Trees

Practically all the young fruit trees set out in this State come from other States. We have received many inquiries from parties desiring information as to the locating of nurseries. It would seem that there

should be no particular difficulty in growing young stock, but, to make sure, we have set out this spring several thousand American and French seedlings for grafting, as well as a number of grafts of the leading varieties.

Ornamental Trees

This subject continues to be one of the most frequently asked of this department, both verbally and by correspondence. We have little to add to the information given in Bulletin 61 of this Station. Unfortunately the edition is exhausted. Many different varieties have been experimented with, but, owing to the extremely adverse conditions of climate existing on the Station farm, many species that would no doubt make additions to our list, if grown in almost any other part of the State, have here failed.

Species of trees, that we know of as having reached ten, fifteen or even twenty years of age in Reno, with us are killed to the ground every winter. As example, we may mention the black walnut and catalpa. Both of these, however, will make a growth of four feet from the root during the summer season.

We desire, however, to bring to your attention three heretofore untried species and as yet not known to be growing in the State outside of the trial ground. They are the cork-barked maple (*Acer campestris*), varnish tree (*Koelreuteria paniculata*), and the so-called coffee tree (*Gymnocladus dioica*).

Cork-barked Maple (*Acer campestre L.*). It is a somewhat shrubby tree not entirely suitable for street planting, although occasionally reaching fifty feet in height. The branches are corky and in this respect not unlike our cork-barked elm (*Ulmus campestris*). The leafage is dense with three- and five-lobed dull-green leaves. It is a slow grower, but stands the irregularities of our winter climate well and will withstand considerable drought.

Varnish Tree (*Koelreuteria paniculata*). A somewhat shrubby species with an irregular rounded head and from twenty-five to thirty feet high. It has large (12 inches long) compound, irregularly toothed leaves, large panicles of yellow flowers in July, and bladdery fruits in autumn. Although a native of Japan and China, it endures our hot sun, drying winds and changeable winters well. Dr. R. H. Loughridge reports having found it growing in soil containing thirty-two tons of alkali salts per acre, including a depth of four feet. It is also one of the few trees or plants that are tolerant of black alkali.

Coffee Tree (*Gymnocladus dioica*). This is a member of the Leguminosæ family, like the locusts, but without thorns. The leaves are from one to three feet long, doubly compound, with seven to thirteen leaflets. It has sprays of white flowers in July and long broad pods in the fall. It gets its name from the fact that the seeds were at one time used to make a beverage that somewhat resembled coffee.

Eucalyptus and English Walnut

Two other frequent inquiries are in regard to the growing of eucalyptus and English walnut in this State. The only part of Nevada that might prove adaptable to some of the species of eucalyptus is Clark County in the extreme south. Even in that region about once in six years there is apt to be a very cold winter which will freeze most of the species to the ground.

During one of these severe winters *Eucalyptus crebra* or ironbark was injured least of all. Those next in order of frost resistance are *E. Stuartiana* or apple-scented gum, *E. viminalis* or manna gum, *E. Polyanthemos* or red box-tree, and *E. rostrata* or red gum. This last-mentioned species will withstand some alkali. The wood is heavy, strong and extremely durable.

E. ruudis stands the heat well and makes an abundant growth during the summer.

E. cornycalyx or sugar gum, *E. hemiphloia* or Australian box-tree, *E. lencoxylon* or white ironbark, and *E. siderophloia* or large-leaved ironbark were all frozen to the ground, but sprouted again from the base.

There are a few English walnut trees growing in the State, but the experiments so far indicate that it would not pay commercially on account of their killing back in the north and the hot dry winds in the south burning up the leaves.

TRIFOLIUM INVESTIGATIONS

We are carrying on both the scientific and practical investigations of the clovers conjointly. From small amounts of seeds collected from the native species in the field we have increased our supply, so that many of them are now under cultivation in beds sufficiently large to determine their utility as forage crops. The monograph of the genus has received a great stimulus by our being allowed to employ an artist. The drawings will be more complete than any work of the kind yet published, as they include the seedling, the whole plant, the variation of the leaves as the plant advances in growth, the flower, legume, and seed.

The status of a number of species grown under cultivation has now been determined, and we will begin publishing these results as circulars, or in the botanical journal, Mühlenbergia.

Next summer we should investigate the Rocky Mountain species in the field, and after that those of Oregon and Washington.

The new greenhouse has been a great help to us in our studies, as it enables us to make observations during the winter months with living specimens which heretofore had to be undertaken with herbarium material. As previously stated in the first part of this report, this is unsatisfactory with so difficult a genus as *Trifolium* and has been the cause of so much confusion in the present literature.

REPORT OF DEPARTMENT OF CHEMISTRY

DR. MAXWELL ADAMS

The work in research chemistry under the Adams Act has been carried on *in absentia* by Dr. C. A. Jacobson. On account of his absence it has not been necessary, nor has it appeared expedient, to add to the supply of chemicals or apparatus. The work accomplished during the past year has been carried out along lines indicated by the report for June, 1911. This present report will attempt only a brief resumé of the work, leaving the details to a separate bulletin, and a personal report by Dr. Jacobson at later date. Through careful work two ketones have been separated from the alfalfa extract which was mentioned in the preceding report. One, myristone, had been previously prepared synthetically, but the other, named by Dr. Jacobson, alfalfatone, is an entirely new chemical compound, which so far as known occurs only in the alfalfa plant. In the separation of the various constituents occurring in alfalfa a knowledge of the chlorophylls contained therein became imperative, therefore a detailed study on chlorophyll was taken up in conjunction with L. Marchlewski at Cracow, Austria. Two monographs containing a total of twenty-four pages were published, wherein the duality of chlorophyll, occurring in plants, was confirmed, and also a method devised for determining the one in the presence of the other.

It has also established in these papers that the ratio of chlorophyll to allochlorophyll varies with different species of plants and also with changing conditions of growth of the same species. These conclusions were deduced chiefly through a study by means of a König-Martens spectorophotometer of the absorptive spectra produced by the various samples of chlorophyll solutions.

By numerous extractions with different solvents neochlorophyllan was separated from chlorophyllan and obtained in the pure state. The knowledge thus gained concerning the properties of chlorophyll was applied to a study of the chlorophyll in alfalfa. The amount present doubtless varies somewhat with different samples of alfalfa, but with that under examination there was found to be 0.68 per cent of chlorophyll present in dry alfalfa hay and 66 per cent of this was neochlorophyll and 34 per cent allochlorophyll. The effect produced by the different conditions of growth upon the quantity of the different kinds of chlorophyll present is still a problem for solution.

A study of the enzymes present in alfalfa seeds has been taken up during the year by Dr. Jacobson in the laboratory of Dr. Hedin, at Uppsala, Sweden, and a number of distinct enzymes detected, one which hydrolyzes starch, one which coagulates milk, one which precipitates purpurogallin, and one which digests casein, like a protease. This protease has been shown by the investigator to be a vegetable erepsin. Further work is being carried out along this and similar lines by Dr. Jacobson at the present time in Dr. Abderhalden's laboratory at Halle in Germany.

The following report of miscellaneous analyses has been submitted by S. C. Dinsmore for this department:

The miscellaneous samples for analysis received at the laboratory and reported on during the year are summarized as follows:

Soils (complete analysis)	16
Soils (alkali)	158
Sugar beets	56
Water (complete mineral)	17
Water (sanitary)	22
Irrigation water	5
Fertilizers	5
Mineral (complete analysis)	43
Miscellaneous	31

REPORT OF DEPARTMENT OF ENTOMOLOGY

SAMUEL B. DOTEN

UNDER THE ADAMS FUND

Project 1—Parasitic and Predaceous Enemies of the Codling Moth.

These studies were continued throughout the year. It became apparent in 1910 that the whole matter of the food of adult hymenopterous parasites had received far too little attention. It seemed probable, in fact that the presence of an abundant food supply for such adults is one of the primary factors which make for the efficiency of such parasitic insects. During the past fiscal year this aspect of the life of these useful insects was given much attention.

It soon became obvious that not only the particular hymenopters under study, but a host of others, derive much food from honey-dew; and it seemed important to discover some of the properties of this substance, and to determine to what extent it is suitable as a food for the insects under discussion. Moreover, it seemed equally important and significant to generalize and to confirm as far as may be possible the results of the preceding fiscal year.

Still, it was not until late in the summer of 1911 that a supply of honey-dew became available for experimentation. Of course, certain honeys made from honey-dew might have been imported for experiment; but there seemed to be some possibility that honey-dew had undergone important chemical modifications in the process of honey-making. The honey-dew which was obtained in quantity was that of the European elm scale, *Gossyparia spuria*. A long rainless summer and autumn gave ample opportunity for the collection of this material on the leaves of infested elms; and late in the autumn it was so abundant that a large quantity of a thick syrup was readily obtained by soaking the leaves for a minute in warm water, then filtering and concentrating the material washed from the leaves. The result of this process was a surprising quantity of a heavy syrup of a rich red-brown color, rich sweet flavor, but with a hint of bitterness like that of hoarhound.

Dr. Maxwell Adams, of the Department of Chemistry of the University of Nevada, became interested in the chemical nature of this syrup, and in the course of the past winter gave it much attention. One of the students in the Department of Chemistry took the study of this honey-dew as a thesis subject; and, as a result, the chemical nature and many of the physical properties of this honey-dew were worked out.

Tests made by the writer showed that a treatment with boneblack with precipitation by fullers' earth followed by filtration would so purify and clarify the syrup as to give it an excellent flavor and all the qualities of a good table syrup from which candy might readily be made in the usual ways. These latter facts are spoken of here simply to indicate the normal sugary nature of this syrup from honey-dew. However, it may be urged that the process of boiling down of washings from

the leaves would make marked changes in the nature of the substance; but chemical tests showed that, beyond a slight reduction of sucrose, owing to the acidity of the washings, no such change occurred. Some precipitation of small quantities of gums did occur, however; but beyond this there was little change to be noted in the final concentrated syrup, of which there are over six quarts now on hand in the laboratory.

Tests of this syrup as food for some sixty species of parasitic hymenopters gave results which will be published at an early date.

Aside from these studies of nutrition and longevity in species feeding on honey-dew, honey, various sugars and the like, further studies were made of the curious Marchal reaction in which the female parasite reacts to the odor of fluids from the punctured host on the withdrawal of the ovipositor and feeds at the puncture.

Other matters, such as secondary parasitism, attacks of predaceous insects on these parasitic hymenopters, the habit on the part of the predatory species which attack the apple worms of feeding during their earlier stages on plant lice, and later of attacking certain secondary parasites of the codling moth, life histories of the species concerned, parthenogenesis in *Microbracon juglandis* in combination with the Marchal reaction—all these and many other matters of interest were developed and studied or established as subjects for future study. Most of them will be published in the course of the present fiscal year.

The salient points of the year's work were prepared as a station bulletin whose publication has been delayed, however, by the difficulty of obtaining identification of the species concerned, a large portion of which are new to science. The identification of the described forms and the description of the new species and new genera is now in the hands of Mr. Henry Lorenz Viereck, of the United States National Museum at Washington, D. C.

It may here be noted that the work with parasitic hymenopters was a means of bringing to light other entomological facts which are apparently of no small interest. Many curious feeding habits on the part of certain diptera were noted, especially Tachina flies and certain mosquitoes.

UNDER THE HATCH FUND

The Alfalfa Weevil.

From time to time in the course of the summer of 1911 reports came to this office of the establishment of this insect in Nevada; but each report proved false, until, at the close of the season, it appeared that Nevada had unaccountably escaped invasion by this pest. As the crop in the hundred or so square miles infested in Utah has been reduced by from one-third to one-half the total, and as two railroads run from the heart of the infested district in Utah through the Humboldt Valley in Nevada, there is every prospect, almost a certainty, of the introduction of this insect into Nevada in the near future, even granting that it does not now exist undiscovered within our borders.

It would seem highly important to undertake patrol work, especially in the Humboldt Valley and in the vicinity of Sparks, Nevada, in order that this pest may be discovered as soon as it is introduced. Once it becomes well established, no power on earth will ever exterminate it; and alfalfa will under the very best of conditions never be raised so cheaply again as it has been raised in the past. Against such a contingency we should guard in every possible way. For these reasons

patrol work is of no small importance under existing conditions. Such patrolling can best be done by student labor, students who are anxious to earn money in the summer with which to pay part of the winter term's expenses in the college; it should prove instructive as well as remunerative. For this work, students of the Agricultural College might best be chosen, owing to the fact that, in contact with the farmers of the district endangered, they may be ready intelligently to answer the various and sundry questions ranging over the whole field of agricultural thought, and far beyond it, which are always asked by the farmers under such circumstances.

Cutworms Injurious to Alfalfa.

In the last annual report of this department mention was made of the depredations of the cutworm of *Euxoa ridingsiana* in the Monitor Valley and in portions of Elko County, Nevada. During the fiscal year 1910–1911 this department collected an abundance of notes and data regarding the later larval stages of this insect, but was unable to secure the earlier larval stages or to complete a study of the species concerned. Against the advice of Mr. F. M. Webster, of the Bureau of Entomology of the Department of Agriculture, Washington, D. C., we did not publish the uncompleted notes, for it seemed quite probable that another summer would yield ample material for study of this same species. However, this estimate proved false, and no information regarding the habits and peculiarities of the species was added in the past fiscal year.

However, there was a fresh outbreak of cutworms in the vicinity of Gardnerville, Nevada, and near Sparks, Nevada, and at Susanville, Cal. This was not *Euxoa ridingsiana*, but another species, as yet undetermined, for reasons which will be stated below. The second injurious species was exceedingly abundant in the infested districts; but, while the *Euxoa* damaged the first crop by preventing it from making a start, the second species damaged only the second crop, attacking the plants just after the hay was mowed, and delaying the growth of the second crop for a period of from two to four weeks, entailing heavy loss.

In the case of the second species it was evident that the cutting of the hay was in itself a check to the cutworms, for they ate the little food remaining completely, and then in a weakened condition fell prey to the attacks of many enemies. They were devoured in quantities by blackbirds which destroyed numbers so great as perceptibly to lessen the injury done to the alfalfa. They were attacked by Tachina flies and other parasitic insects, but hymenopterous parasites were not abundant.

Among the mechanical remedies tested was a thorough disking and cross-disking of the infested fields, and the use of brush-drags; but neither method made any apparent difference, though it was evident that both methods destroyed large numbers of the worms. In a field which had been flooded many dead worms were found, apparently drowned by the water running in the furrows at night. This field immediately became green and made a good stand of hay, but the change in its condition was not due so much to the drowning of the worms as to an epidemic disease which broke out among them. Damp and cloudy weather seemed to favor the development of the disease, which took the form of an epidemic diarrhea. The cutworm when attacked mounted some prominent stalk of the alfalfa, crawling upward and toward bright light in the daytime, which is unusual, and clung there on the alfalfa stem until

death. Just before death, or shortly before, the contents of the bowels were discharged in a long smear down the stalk, and not infrequently the green rind of the stalk was subsequently gnawed by other worms, suggesting an excellent means for the propagation of the disorder. Of some 300 worms of this species which were brought to Reno, nearly all died in forty-eight hours from this disease. In the cages and in the field on calm days there was a peculiar and characteristic odor from the diseased worms. The body-fluids of the sick worms were full of a small motile organism, apparently a bacterium, possibly pathogenic in character.

The disease, with the other natural enemies of the cutworms under examination, together with the pupation of a few survivors, so decreased the numbers of worms that after some weeks' delay the alfalfa made a normal stand, but too late in the season to make the usual beginnings of a third crop. It is probable that this species, which is much commoner throughout Nevada than *Euxoa ridingsiana*, will appear in numbers sufficient to permit of its thorough study in the course of the present summer.

The European Elm Scale

Certain trees on the University Campus were infested with this insect to some extent in 1910 and 1911; but it was not until the spring of 1912 that they became noticeably abundant on the Campus elms. However, their abundance gave excellent opportunity for washing with the strong stream from the garden hose; and this was undertaken rather late in the spring of 1912, when the leaves were already somewhat advanced on the elms. At this season the female scales were all engorged, but had laid no eggs. The secretion of honey-dew was very evident. The male cocoons, looking like tiny grains of rice, gave a clue to the position and the abundance of the females.

The plan adopted in washing these elms was as follows: The man employed was dressed with a heavy slouch hat, a waterproof ulster, and boots or rubbers. He was equipped with nearly 300 feet of garden hose to which was attached a six-foot extension of $\frac{3}{4}$-inch galvanized pipe to which was attached a nozzle which would project a hard round stream for ten or twelve feet from the nozzle; on the taller branches he used a short stepladder. The limbs were washed most thoroughly from four sides of the tree. From an hour to an hour and one-half was devoted to each of the larger trees, every little crotch in the system of limbs receiving special attention.

One week after the first washing the man employed in this hard and disagreeable task went over all the trees again, climbing many of them and examining the branches very carefully; then washing with the full force of the stream every branch that had been missed. The object of these tests was simply to find out whether by a single most thorough washing one may clean an elm of this scale insect so thoroughly that it will not seriously injure the tree in the course of the subsequent summer and autumn.

It is obvious from the fact that the gravid females are by far oftenest found on the under sides of the lower branches that washing will rid the tree of great numbers of such females, and, if it is done before they deposit their eggs, the number of young will be correspondingly decreased. But this will not prevent or hamper the reintroduction of the larval stages of the pest on the feet of birds or of various insects which fly from

tree to tree. In fact, the very honey-dew, which is a source of food to the visiting diptera and hymenoptera, is apparently indirectly in this way a provision for the spread of the scale insects in question.

Miscellaneous Work in Entomology.

In the course of the past fiscal year the number of inquiries for information regarding insect pests and various forms of insect life increased greatly over that of previous years. This necessitated the employment of no small amount of time in correspondence and in looking up answers to the numerous questions propounded. Such inquiries are very welcome, for they show a growing interest in the Experiment Station on the part of the people of the State.

REPORT OF
DEPARTMENT OF METEOROLOGY AND CLIMATOLOGY

J. E. CHURCH, JR.
S. P. FERGUSSON

The following bulletins and reports will furnish a detailed statement of the work and plans of the department until the present year:

Bulletin No. 67—The Mount Rose Observatory, 1906-1907; Bulletins No. 66, p. 69, and No. 72, p. 49 ff; No. 73½, p. 53 ff., and the annual report for the year ending June 30, 1911; Bulletin No. 77—The Avoidance and Prevention of Frost in the Fruit Belts of Nevada.

The projects now being directed by this department are:

1. The Forecasting of Frosts from Mountain Tops.
2. The Relation of Topography to the Occurrence of Frost.
3. The Temperature Survey of the State.
4. The Relation of Mountains and Forests to the Conservation of Snow.

Of the above projects, Nos. 1, 2, and 4 have been planned and administered under the Adams Act; No. 3 is to a large extent routine work and has been supported by state funds granted by the Legislature for the support of the department.

1. The Forecasting of Frost from Mountain Tops

Under the above project is contemplated the study of the relation of storm movements on mountain tops to temperature changes in the valleys below. To trace these movements, meteorographs have been placed at Truckee, on the summit of Mount Rose, and at Fallon, and a thermograph and barograph at Tahoe City. Excepting damage to the anemometer on Mount Rose, these instruments are running regularly and data are being systematically obtained.

A measurably complete equipment has been gathered for obtaining the temperature of the free air by means of thermographs borne by kites. The purpose of obtaining such temperatures is the determination of the error in the records on Mount Rose through the influence of the mountain mass upon the adjacent air.

Stations for refuge and headquarters are maintained at Mount Rose Ranch, Contact Pass, and on the summit. These stations are also used in the prosecution of the snow studies.

2. The Relation of Topography to the Occurrence of Frost

This project connects Project 1 with Project 3. It is the natural sequence of the former and should furnish the principles essential to the ideal prosecution of the latter.

The plan contemplates the placing of delicate instruments for the study of the movement of air and temperature currents at the top and bottom of typical slopes and the placing of a third set on Morrill Hall or other high structure to determine the contemporaneous movement of the free air.

Much of the material for these instruments has already been procured, and the initiation of the work depends only upon their completion.

3. The Temperature Survey of the State

The temperature survey of the State was begun one year ago by the establishing of four stations—one each at Glenn's, Plumb's, and Clow's Ranches, and at Church's orchard. Records from the Station Farm were borrowed to supplement the series of data being obtained. During the present season additional stations have been established as follows:

TRUCKEE MEADOWS

1. To determine the limits of Thermal Belt No. 1—
   - (1) Wiley's Orchard, near present railway station, Verdi.
   - (2) Snare's Ranch, 3 miles east of Reno.
   - (3) Patrick's Ranch, on Arlington Heights.
   - (4) Pecetti's Ranch, where Steamboat Ditch crosses Mount Rose road.
   - (5) On Highland Ditch, above city reservoir.
2. To determine the limits of Thermal Belt No. 2—
   - (6) Brown's Ranch, on Virginia Road, ten miles south of Reno.
   - (7) University Campus (thermometers loaned by Professor Smith).
3. To determine the temperature at lower end of meadows—
   - (8) Alt's Ranch at Glendale.

GALENA CREEK

- (9) Mount Rose Ranch. (Instrument loaned by Professor Fergusson).
- (10) James Callahan's Ranch.

TRUCKEE-CARSON PROJECT

- (11) W. W. Cogswell's Ranch, one mile south of Argo.

This will supplement the records obtained on the large meteorograph at the Experiment Farm near Fallon.

With one exception, these stations are cared for free of cost by the owners of the ranches upon which they are placed. The exception is the station above the city reservoir, where the keeper, Mr. C. E. Cole, has been hired to change the record sheets at a compensation of 25 cents a week.

The instrument at Mount Rose Ranch has a range of thirty-two days and must be reset by one of the staff.

The temperature survey has been productive of beneficial results. Practically all who have undertaken the care of the stations have declared their intention of engaging in orchard heating. Furthermore, the suitability in point of temperature of the higher slopes of the Truckee Meadows for fruit growing has been strongly indicated. Bulletin No. 79 sets forth this subject in detail.

Last year three individuals began orchard heating in the Truckee Meadows. This season the number has been increased by the addition of the following: Mr. Wiley and Mr. Hill, Verdi; Mr. Patrick and Mr. Frey, near Reno. However, since orchard heating lies in the twilight zone between the Departments of Meteorology and Horticulture, this work should be shared with the latter department or left to it entirely.

It is regrettable that the material for the new temperature stations did not arrive in time to establish any stations in the more remote portions of the State, for the granting of an appropriation for this purpose by the State Legislature made it desirable to inaugurate the work in more centers than one. However, under the present plan, the Truckee Meadows can now be surveyed with more thoroughness than would otherwise have been possible. If material for a few more stations can be procured during the coming year (the total for the entire survey not to exceed twenty-five), these should be placed in the Little Humboldt and Upper Humboldt Basins.

Further refinements in frost forecasting are being made during the present season, which indicate that the minimum temperature of any morning can ordinarily be predicted within three degrees on the night previous. If fruit growers can be trained to study frost forecasting, they can be freed from much perplexity regarding the probable occurrence of frost and can save much of the energy otherwise spent in watching. A system of frost alarms should supplement the forecasting, but not usurp its place.

4. The Relation of Mountains and Forests to the Conservation of Snow

During the present season systematic and frequent measuring of the snow has been done in the Tahoe Basin. Courses have been laid out at Tahoe City, Ward Creek Divide, Blackwood Creek, McKinneys, Rubicon Range, Tallac, Mount Tallac, and Glenbrook. Intensive study of the action of the snow under the influence of shade, shelter, and exposure to sun and wind have been made at Tahoe City and Blackwoods.

The evaporation of the snow has been measured whenever the weather has been settled enough to make even approximate accuracy of the measurements possible. The available moisture over the watershed of Lake Tahoe has been estimated during the spring, and the data obtained in the measurements at the various elevations have been placed at the service of the Truckee River General Electric Company for the regulation of the lake level.

The continuation of this work for a series of years is of prime importance, not only for refining the measurements already obtained, but for the advancement of the study of the effects of slopes of various kinds and forestation on the maximum conservation of snow. The final results should throw much light on ideal forests and forest pruning, and the relation of forest covering to floods.

A preliminary bulletin on "The Relation of Mountains and Forests to the Conservation of Snow" is in preparation.

During the summer vacation of 1911 Professor Fergusson visited McGill University, Montreal, to study the system of forecasting from Mount Royal established by Professors McLeod and Barnes, and in addition to discussing the work with these gentlemen obtained a complete set of papers containing the results of this study. Also, considerable time was spent at Blue Hill Observatory, Massachusetts, where parts of new instruments for this department were constructed and assembled. About 500 valuable technical papers from the duplicates in the Blue Hill library were presented by Director Rotch. Two further additions to the library of the department were secured, one of which comprises the meteorological library of the late Charles W. Friend of Carson City, founder of the Nevada State Weather service, the other being a part of the library of

the late Frank W. Proctor of Fairhaven, Mass., which was presented to Professor Fergusson by the executors of the estate. These publications, many of which are by distinguished workers in meteorology, form one of the best and probably the most complete libraries in the West, and are being catalogued, without expense to the department.

On June 7, the department moved to a large room on the third floor of Morrill Hall, where adequate space for library and study is available. Materials have been obtained for the construction of apparatus for recording the chief elements of the weather, the records to be employed in research and in giving instruction.

REPORT OF DEPARTMENT OF VETERINARY SCIENCE AND BACTERIOLOGY

W. B. Mack

EQUINE ANEMIA

The study of equine anemia has occupied the major portion of our time during the year. Inoculation experiments have been continued. In order to avoid the possibility of the existence of immunity in animals procured in the infected districts, it appeared best to procure subjects for inoculation from a section remote from there. Accordingly several horses were purchased near Reno and shipped to the ranch where our branch laboratory is located. These animals were inoculated in December, but as yet there is no result apparent from the experiments.

There have been but a few cases during the year, so that but a little fresh material has been obtainable. Two trips have been made to the valleys on the east side of the Ruby Mountains in an effort to confirm the reported occurrence of this disease there. No cases were found on these visits. It is probable, however, from the descriptions given by several ranchmen there, that horses have died from this disease on that side of the range at various times during the past few years. We shall endeavor in future to keep in touch with the conditions in that region as well as in the territory formerly under observation.

A paper entitled "Intracellular Bodies Associated with Equine Anemia," describing the bodies found within the red blood corpuscles of animals affected with that malady, referred to in our last annual report, was presented to the last annual meeting of the American Veterinary Medical Association and published in their proceedings for 1911, pages 378-382.

HOG CHOLERA

Hog cholera again appeared in western Nevada during the summer and autumn of 1911. The losses were, as usual, severe. In many instances the owners bore the loss in silence, the existence of the disease on their ranches being learned indirectly some time afterward. Particularly was this the case with the Italians. The trouble was reported to us by the owners of several herds and the Dorset-Niles hog cholera serum used. In every such instance the disease was promptly checked by the use of the serum.

We have prepared some of this serum and shall endeavor, in future, to keep on hand a sufficient quantity to meet the needs of our people. Considerable work will be necessary, however, to convince the hog raisers generally that this disease can be effectually prevented and controlled and most of the losses avoided by this method. A popular paper on hog cholera and its control is in course of preparation and will be published shortly in an endeavor to meet this need.

REPORT OF
DEPARTMENT OF LIBRARY

MRS. T. W. COWGILL

The accessions to the Library for this year consist of 168 volumes and the usual unbound matter. To relieve the increasing congestion, it is important that a considerable amount of binding be done in the ensuing year, and that another bookstack be added to the equipment.

It is gratifying to note that this library is used for reference by students, and others interested, with increasing freedom.

AVAILABLE BULLETINS OF THE
NEVADA AGRICULTURAL EXPERIMENT STATION

17. The Woolly Aphis of the Apple.
23. Sugar Beets.
28. An Important Elm Insect.
29. The San José Scale.
30. Wheat-Cutting at Different Dates.
31. Texas Cattle Fever.
32. Sugar Beets.
33. Field Notes on Some Nevada Grasses.
39. Some Nevada Soils.
40. Pig Feeding.
43. Sugar Beets.
44. Sugar Beets.
45. Twigs of Common Trees and Shrubs.
47. Clover Seeds and Their Impurities.
49. The Carpenter Worm.
50. Sugar Beets.
51. A Preliminary Report of the Summer Ranges of Western Nevada Sheep.
52. Water Supply and Irrigation in Nevada.
53. Burning Dead Animals.
54. Report of Irrigation of the Humboldt River Valley, Nevada.
56. Crickets.
62. Native Forage Plants and Their Chemical Composition.
64. Digestion Experiments with Native Hay.
65. The European Elm Scale.
66. Annual Report, 1908.
69. Irrigation Laws and Litigation in Nevada.
70. Food and Drug Inspection.
71. Digestion Experiments on the Range.
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AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Annual Report of the Board of Control for the Fiscal Year Ending June 30, 1913

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

CARSON CITY, NEVADA
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
1914

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AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Annual Report of the Board of Control, The Director, and the Members of the Station Staff

For the Fiscal Year Ending June 30, 1913

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

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THE AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

The Hon. Hosea E. Reid (1911–1915), Chairman........Reno
The Hon. Charles B. Henderson (1911–1915)........Elko
The Hon. Arthur A. Codd (1913–1917)........Reno
The Hon. James W. O'Brien (1913–1915)........Sparks
The Hon. Walter E. Pratt (1913–1917)........Goldfield
Mr. George H. Taylor, Secretary........Reno
Mr. Charles H. Gorman, Comptroller........Reno

STATION STAFF

Joseph Edward Stubbs, LL.D.[1]........President
Robert Lewers........Vice- and Acting President
Gordon H. True[2]........Director and Animal Husbandman
Patrick Beveridge Kennedy, Ph.D........In charge of Botany, Horticulture and Forestry
A. Arthur Heller, Sc.D.[2]........Assistant in Botany, Horticulture and Forestry
Frank L. Peterson, B.S.........Irrigation Engineer
Samuel Bradford Doten, M.A.........Entomologist
Winfred Berdell Mack, D.V.M.........Bacteriologist and Veterinarian
James Edward Church, Jr., Ph.D.........Meteorologist
Sterling Price Fergusson........Associate Meteorologist
Carl Alfred Jacobson, Ph.D.........Chemist
Ernest Albert Howes[2]........Agronomist
Peter Frandsen, A.M.........Consulting Biologist
Maxwell Adams, Ph.D.........Consulting Chemist
Leslie Theodore Sharp, B.S.........In Charge of Soil Investigations
Verner E. Scott, B.S.........Consulting Dairy Husbandman and Assistant Animal Husbandman
Charles Leroy Brown, M.A.[2]........In Charge of Eelworm Investigations
Theodore W. Clark........Superintendent of Farm
Mrs. T. W. Cowgill, M.A.........Librarian
Mrs. Louise Blaney........Station Secretary

[1]On leave of absence, 1912–1913. [2]Resigned June 30, 1913.

LETTERS OF TRANSMITTAL

RENO, NEVADA, January 5, 1914.

To His Excellency, TASKER L. ODDIE, *Governor of Nevada.*

SIR: I have the honor to submit herewith the Annual Report of the Board of Control of the Nevada Agricultural Experiment Station for the fiscal year ending June 30, 1913.

HOSEA E. REID,
Chairman of the Board of Control,
Nevada Agricultural Experiment Station.

GEO. H. TAYLOR, *Secretary.*

AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF NEVADA,
RENO, NEVADA, June 30, 1913.

HON. HOSEA E. REID, *Chairman Board of Control, Nevada Agricultural Experiment Station.*

SIR: I have the honor to transmit herewith the Annual Report of the Agricultural Experiment Station for the year ending June 30, 1913.

Respectfully submittted,

ROBERT LEWERS,
Acting President.

FINANCIAL REPORT

Nevada Agricultural Experiment Station

IN ACCOUNT WITH

The United States Appropriations, 1912–1913

Items	Abstract	Hatch Fund	Adams Fund
Debtor			
To balance from appropriations for 1911-1912			
Receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1913, under Acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund)		$15,000.00	$15,000.00
Creditor			
By salaries	1	$8,809.27	$11,308.10
By labor	2	2,392.20	313.45
By publications	3	20.00	
By postage and stationery	4	396.64	29.53
By freight and express	5	196.11	71.02
By heat, light, water, and power	6	117.05	124.50
By chemicals and laboratory supplies	7	304.89	191.77
By seeds, plants and sundry supplies	8	386.99	135.93
By fertilizers	9		
By feeding stuffs	10	25.38	252.10
By library	11	.54	10.71
By tools, machinery and appliances	12	232.58	32.00
By furniture and fixtures	13	348.95	70.00
By scientific apparatus and specimens	14	199.50	261.10
By live stock	15	139.00	3.50
By traveling expenses	16	496.80	646.94
By contingent expenses	17		15.00
By buildings and land	18	209.10	51.05
Unexpended June 30, 1913		725.00	1,483.30
Totals		$15,000.00	$15,000.00

SUPPLEMENTARY STATEMENT

Items	State appropriations	Fees	Farm products	Miscellaneous	Totals
Debtor					
To balance on hand	$2,379.87		$145.72		$2,525.59
To receipts from other sources than the United States	5,000.00		189.70		5,189.70
Totals	$7,379.87		$335.42		$7,715.29
Creditor					
By salaries	$1,050.00				$1,050.00
By labor	25.65		153.25		178.90
By publications					
By postage and stationery	.96				.96
By freight and express	3.96				3.96
By heat, light, water, and power	5.00				5.00
By chemicals and laboratory supplies	266.64				266.64
By seeds, plants and sundry supplies	224.88		33.50		258.38
By fertilizers					
By feeding stuffs	456.00				456.00
By library					
By tools, machinery and appliances	32.70		6.92		39.62
By furniture and fixtures	238.00				238.00
By scientific apparatus and specimens	485.68				485.68
By live stock					
By traveling expenses	40.40				40.40
By contingent expenses					
By buildings and land					
By balance	4,550.00		141.75		4,691.75
Totals	$7,379.87		$335.42		$7,715.29

C. H. GORMAN, *Comptroller*.

REPORT OF THE DIRECTOR

To the Acting President of the University of Nevada.

SIR: I have the honor to submit herewith in obedience to the Congressional Acts of March 2, 1887, and March 16, 1906, my second annual report. This report covers the work of the Station from June 1, 1912, to June 30, 1913.

The following changes have been made in the organization of the departments of the Station for the year ending June 30, 1913:

Professor E. A. Howes, of the Seed Branch of the Department of Agriculture of the Dominion of Canada, took up his work as Professor of Agronomy in the University and Field Husbandman in the Station in August, 1912, but resigns at the end of the fiscal year, June 30, 1913.

Mr. L. T. Sharp came from the University of California to take charge of soil investigations.

Mr. Chas. L. Brown, who has been in charge of the eelworm investigations—a special project under the Adams Fund—severs his connection with the Station at the end of the fiscal year and the project will be discontinued.

Professor A. A. Heller, Assistant Botanist, Horticulturist, and Forester, also leaves the Station at the close of the fiscal year, as does Professor Gordon H. True, Director.

Mr. V. E. Scott, elected as Instructor in Dairying, August, 1912, has acted as Assistant in Animal Husbandry in the Station.

Dr. C. A. Jacobson, Research Chemist, who was abroad conducting investigations in European laboratories during the last year, returned to the Station in March, 1913.

Dr. P. B. Kennedy, Station Botanist, continues to serve as Chairman of the Board of Control of the State Experimental Farm at Logan, Clark County, Nevada; and Professor Gordon H. True continued to serve as Secretary of the Board of Control of the Elko County Dry Farm. Biennial reports for these two state experimental farms have been issued.

Of the legislative appropriations granted for the support of the Station for the biennial term of 1911 and 1912, about $1,000 remained for expenditure during the past year. The Legislature of 1913 made the following appropriation: For the support of the Experiment Station for two years, $5,000.

ADAMS FUND PROJECTS

The projects in hand under the Adams Fund have been continued and a detailed account of each will be found in the departmental reports.

NEW ADAMS FUND PROJECTS

During the year the following new projects were approved by the Office of Experiment Stations and begun:

Soils Research, Project 1—The biological fixation of nitrogen for agricultural purposes.

Project II—A study of the bacterial flora and activity in soils as affected by irrigation. As these were approved late in the year and some delay was experienced in equipping the soil laboratory, they were not more than begun.

In the Department of Chemistry a study of the essential oils of several species of pines was approved under the Adams Fund and begun.

PROJECTS DISCONTINUED

The potato eelworm investigations are to be discontinued at the end of the fiscal year on account of lack of state funds to carry them on. The notes on this investigation will be published later.

WORK UNDER HATCH FUND

Work was carried on under the Hatch Fund by the Department of Agronomy (Field Husbandry) in the matter of a series of soiling experiments in cooperation with the Department of Animal Husbandry. Other problems worked on during the year by the Department of Agronomy were that of growing corn in Nevada for ensilage, a continuation of the experiment in the different rates of irrigation, the growing of Canada field peas carried on with the Department of Animal Husbandry to test the value of these as a hog-finishing product. An experiment was carried on by the Department of Animal Husbandry on the comparison of alfalfa hay and alfalfa silage as a feed for dairy cows.

Under the Hatch Fund the Department of Botany, Horticulture, and Forestry had in hand the following problems: Vegetable gardening, drug-plant investigations, orchard investigations to determine the influence of irrigated and nonirrigated acres of apple orchard on the growth of trees in the production of fruit, and frost-fighting investigations. The orchard investigations have been in operation for ten years, and may now be considered complete. Grass and forage-plant investigations were continued; this has in mind to determine the grasses and forage plants of economic value on the ranges and native meadows of the State.

Under the Hatch Fund the Department of Entomology carried a minor project in the study of methods of washing elms infested with European elm scale. This project was completed and a successful method worked out.

The irrigation experiments in the grain crops of White Australian wheat were continued on the same schedule as in the preceding four years.

COOPERATIVE WORK

In the agreement between the U. S. Department of Agriculture, the Nevada Experiment Station, and the State Engineer, the work in irrigation investigations proceeded according to the articles of agreement. The field work of irrigation investigations for the past year has been a hydrographic study of the valley of the Humboldt; the principal valley studied thus far has been the Lovelock. The work in the soil-tank experiments has been continued on the Experiment Station Farm.

This year we have had several farmers cooperating with us in variety tests. In this connection a tentative Experimental Union of twelve members has been formed. The members of this union are trying out three varieties each of wheat, oats, barley, and peas in plots of one-tenth acre in size. The Station is trying out the same varieties in duplicate.

During the past year the Department of Agronomy installed a seed germinator and did considerable seed testing at the Station for farmers. The Department of Soils Research made analyses of over fifty typical samples of Nevada soils.

There has been no extension work done by the Station further than the cooperative experiments named above, and a fairly considerable amount of correspondence in answer to questions from people in the State, and a few newspaper articles.

STATION PUBLICATIONS

There have been no bulletins published during the past year. The State Legislature at its last session extended an increase of the printing privileges of the Experiment Station so that a monthly 16-page pamphlet in an edition of 1,500 is issued from the State Printing Office at Carson City, Nevada. This has been named "Better Farming," and covers timely and practical articles by the various members of the Station staff.

APPROPRIATIONS

Federal—Hatch Fund	$15,000
Federal—Adams Fund	15,000
State—Support of Experiment Station	5,000

DEPARTMENTAL REPORTS

The reports of the several departments of the Station are herewith given. Each gives a complete account of the work done by the department under the Hatch and Adams Funds. The departments are as follows:

1. Department of Agriculture and Animal Husbandry.
2. Department of Botany, Horticulture and Forestry.
3. Department of Chemistry.
4. Department of Entomology.
5. Department of Meteorology and Climatology.
6. Department of Veterinary Science and Bacteriology.
7. Department of Library.

The reports of the Department of Food and Drug Control and of the Department of Weights and Measures are published separately.

I have the honor to remain

Yours, very truly,

GORDON H. TRUE,
Director.

DEPARTMENTAL REPORTS

DEPARTMENT OF AGRICULTURE AND ANIMAL HUSBANDRY

GORDON H. TRUE, Animal Husbandry
ERNEST A. HOWES, Agronomy
FRANK L. PETERSON, Irrigation
LESLIE T. SHARP, Soils
VERNER E. SCOTT, Dairying

IRRIGATION EXPERIMENTS

The irrigation experiments in the grain crops of White Australian wheat and Siberian oats were continued on the same schedule as in the preceding four years. Two acres, containing eight one-fifth-acre plats and two one-tenth-acre plats are devoted to each crop. The object of the experiment is two-fold: first, from the viewpoint of the irrigationist, is a study of the relation of the time and amount of irrigation upon the yield of the grain; second, from the viewpoint of the agronomist, the influence of the time and amount of irrigation upon the gluten content of the grain. The schedule of irrigation is based upon the time of heading of the grain (July 1 to 5) and varies from three irrigations before and two after heading (maximum application) to one before and one after heading (minimum application). The fifth-acre plats are each separated by a three-foot walk. Each fifth is diked and irrigated by the flooding system. The soil is a heavy type and there is no interference by later movement of water in the soil. Measurements of water are made by means of a Cippoletti weir.

White Australian Wheat

Area in acres	Irrigations		Yield in pounds	Yield in bushels per acre	Depth of water applied in feet	Yield per acre-foot water in bushels
	Before heading	After heading				
One-fifth	3	2	453	37 bu. 45 lbs.	1.76	21 bu. 26.9 lbs.
One-fifth	3	1	467	38 bu. 55 lbs.	1.26	30 bu. 56.1 lbs.
One-fifth	2	3	446	37 bu. 10 lbs.	1.25	31 bu. 32.5 lbs.
One-fifth	2	2	549	48 bu. 25 lbs.	.92	49 bu. 43.7 lbs.
One-fifth	2	1	364	30 bu. 20 lbs.	1.25	24 bu. 21.8 lbs.
One-fifth	1	3	428	35 bu. 40 lbs.	1.39	25 bu. 35.1 lbs.
One-fifth	1	2	477	39 bu. 45 lbs.	1.32	30 bu. 9.5 lbs.
One-fifth	1	1	332	27 bu. 40 lbs.	1.08	25 bu. 35.6 lbs.

Siberian Oats

One-fifth	3	2	282	44 bu. 2 lbs.	1.8	23 bu. 31.5 lbs.
One-fifth	3	1	245	38 bu. 9 lbs.	1.36	28 bu. 2.0 lbs.
One-fifth	2	3	292	45 bu. 20 lbs.	1.87	24 bu. 18.5 lbs.
One-fifth	2	2	239	36 bu. 23 lbs.	1.64	22 bu. 11.5 lbs.
One-fifth	2	1	234	36 bu. 18 lbs.	1.05	34 bu. 21.0 lbs.
One-fifth	1	3	312	48 bu. 24 lbs.	1.48	32 bu. 31.5 lbs.
One-fifth	1	2	340	53 bu. 4 lbs.	1.08	49 bu. 7.5 lbs.
One-fifth	1	1	232	36 bu. 8 lbs.	.89	40 bu. 18.9 lbs.

Cooperative Work with Irrigation Investigations, United States Department of Agriculture

In a triangular cooperative agreement between the United States Department of Agriculture, the Nevada Agricultural Experiment Station, and the State Engineer, the work in irrigation investigations has proceeded according to the articles of the agreement. The work in the soil-tank experiments is located on the Experiment Station Farm. The experiment during 1912 was enlarged by the addition of six tanks, set concentric with the old alfalfa tanks, and the study of the water requirements of crops was extended to club wheat. The results of the alfalfa tank series seem to warrant that the results are close enough so that we can empty the tanks and use them for oats the coming season. The results of the experiments under the cooperative agreement will be submitted to Washington, D. C., where they will be compiled in conjunction with similar work of other Experiment Stations in the West. After the results have been checked and approved they become available as material for the Station.

The field work of irrigation investigations for the past two years has been a hydrographic study of the valley of the Humboldt. The valley of the Humboldt River is divided into a number of distinct valleys by the river passing through various narrows or canyons. The principal valley studied thus far has been the Lovelock Valley, and the duty of water under the canals in the same. During the coming year automatic gage height recorders will be installed on the heads of the canals so that the work in the Lovelock can be continued without much additional cost and a study of the duty of water extended to the central or Battle Mountain Valley. In addition to the duty of water, evaporation measurements have been made from two places on the Humboldt by floating a type of wave-protected pan, one being located in the Lovelock Valley and the other at Winnemucca, Nevada.

AGRONOMY

The report for the year ending June 30, 1913, is largely a list of things started and results hoped for. When the writer took over the work at this Station, he was given full liberty to make what changes he deemed necessary and to attempt whatever new things he considered advisable. A few outstanding considerations governed the agronomist's work for the year, as shall here be outlined, and these considerations were as follows:

1. The importance of agronomy to this or any State called for more field experiments.

2. Field crop work being so new in Nevada and climatic and other conditions being so unusual, a series of variety tests might well become the foundation of the experimental work.

3. Agricultural areas being so widely separated, and the Experiment Station Farm being, as a consequence, comparatively isolated, it was thought well to institute a series of cooperative experiments as checks on the experiments carried on at the Station, and for the purpose of interesting individuals and localities more directly in the work being done at the Station.

4. While always advisable to secure the very best seed obtainable for

foundation stock, it was in addition advisable here to look toward obtaining the hardiest seed that could be found. The source of all the seed sown will be given in detail.

Soiling Crops

In addition to the variety tests just mentioned, the Department of Agronomy has sought to cooperate with the Department of Animal Husbandry in the matter of a series of soiling tests now under way. This is mentioned at this stage because it was the only work, aside from soil preparation, carried on following the harvest of 1912 (the result of the crop irrigation experiment will be given by the irrigation engineer). Two acres, Nos. 13 and 14, were sown to winter rye and hairy vetch (mixture) to grow early green feed for the cattle used in the soiling experiment. The seed was sown early in the fall and a fair growth of rye and vetch was secured before winter. During the winter most of the vetch that had germinated was killed back, but with the warmer weather this spring a strong growth began and we have had an early and abundant yield. Definite data will be given by the Animal Husdandry Department when the experiment is completed. We have cut the two acres over once and a second growth of over 18 inches stands on the strip first cut.

We are now starting to cut acre No. 29, first crop of alfalfa to carry on this soiling experiment. To follow this we have a small plot of mixed peas and oats, and to follow that we have another plot sown to common millet. To guard against lack of feed we have acres 15, 18, 19, 29, in alfalfa, which we can manipulate so as to secure an alfalfa ration when desired by those in charge of the feeding experiment. When 13 and 14 have been cut over once more we shall plow under any further growth and prepare these plots for variety tests of autumn-sown crops.

The Experimental Farm is laid out in divisions of one acre each, the irrigation ditches being run to conform with this arrangement. These acres have retained the same numbers for some years, and they will be referred to by these numbers as indicated on a chart of the farm.

No. 3—The sugar-beet industry is attracting a great deal of attention in Nevada, and as a consequence certain problems in the culture of sugar beets may well form a part of the work of the Station. At the suggestion of the agriculturist of the beet-sugar company at Fallon, we have undertaken an experiment to test the comparative effects of different dates of planting. Beginning on April 16 we have sown three rows to sugar beets each week, and we shall make our final seeding on July 2. Our rows are 30 inches apart and we are thinning to 1 foot apart on the row. Our plots are separated by 4-foot paths. The seed used to form the stock is from the stock sown by the patrons of the beet-sugar factory at Fallon.

No. 4—This acre was planted to corn last year. The physical condition of the soil left much to be desired. It has been sown to Marquis wheat, 75 pounds to the acre, and has been seeded down to Red clover. It is the intention to plow a crop of the clover under next year. At present there is a splendid stand of wheat and a first-class "take" of clover.

No. 6—Here we have twelve varieties of potatoes, three rows of each variety, planted in rows 3 feet apart, 5 feet between varieties. Following is a list of the varieties and the source of the seed:

Early Red, grown by C. Ross, Red Rock.
Peerless, grown by C. Ross, Red Rock.

Burbank, grown by C. Ross, Red Rock.
Great Divide, grown by J. Callahan, Washoe.
Early Ohio, purchased from St. Paul, Minn.
Irish Cobbler, purchased from St. Paul, Minn.
Rural New Yorker, purchased from St. Paul, Minn.
Carman No. 2, purchased from St. Paul, Minn.
Early Russet, purchased from St. Paul, Minn.
Netted Gem, purchased from St. Paul, Minn.
Improved Rose, purchased from Mitchell, South Dakota.
Gold Coin, purchased from Mitchell, South Dakota.

The potatoes were planted May 23 and are making a good showing, particularly the potatoes purchased locally. We aimed to get potatoes for seed that we were reasonably certain were free from the eelworm contamination.

No. 21—In this acre we have sown eighteen varieties of field roots—five of mangels, four of carrots, five of Swedes turnips or rutabagas, and four of cow or field turnips. The rows are 30 inches apart and we are thinning the mangels and turnips to 15–18 inches in the row and the carrots to 8–10 inches. The seed was purchased, with one exception, from Toronto, Canada. The varieties are as follows:

Mangels—Yellow Globe, Golden Tankard, Yellow Intermediate, Long Red, Royal Giant Sugar.

Carrots—Short White, White Belgian, White Vosges, Long Orange.

Swedes—Selected Purple Top, Canadian Gem, Jumbo, Hartley's Bronze Top, Kangaroo.

Field Turnips—Graystone, Flat Norfolk, White Globe, Cow Horn.

The one exception mentioned is the Tankard mangel, "Our Ideal," the seed of which was purchased from Waterloo, Ontario. This seed was grown at Waterloo; the other seed was presumably grown in Europe. In plot tests conducted at Ottawa, Canada, a year ago, the writer had the opportunity of trying out 282 strains of field roots, and the eighteen varieties being tried out at this Station were purchased on the results of those tests, being the most successful from point of yield, hardihood, and uniformity and trueness to type.

Field roots are comparatively new in Nevada and should form a welcome addition to the finishing ration for stock.

No. 12—Divided by paths running lengthwise and crosswise, this acre consists of thirty plots of one thirty-sixth of an acre each, of clovers, grasses, millets, etc. This acre is intended as a sort of demonstration area, although comparative yields from the plots should be recorded and suitability of crop and variety determined. The plots are sown as follows:

Clovers—Crimson, Common Red, Mammoth Red, Alsike, White.

Alfalfa—Ontario Variegated, Grimm, Turkestan, Nevada Dry Farm, Nevada Irrigated.

Grasses—Western Rye, Perennial Rye, Red Top, Canadian Blue, Timothy, Meadow Foxtail, Orchard, Awnless Brome, Meadow Fescue.

Millets—Golden, Siberian, Japanese, Hungarian, Common, Hog, Early Fortune.

Einkorn, Emmer (Spring), Spelt.

No. 17—In this acre we have, in rows five feet apart, sixty-six strains of alfalfa. Fifty-four of these were furnished us by the Department at Washington; the remaining fourteen are from individual plants, grow-

ing on the hills in the vicinity of Reno. These plants were selected for certain individual characteristics, now a matter of record, and with the idea of developing a hardy Nevada strain. The plants from some strains of seed are now about six inches high, while other strains are making a poor showing to date. It is the intention to maintain these rows of alfalfa for some time, for demonstration purposes, and to determine comparative suitability to Nevada conditions.

Nos. 20, 21, 22, 23—Last year the Station reported the results of a fourth-year experiment in the matter of different rates of irrigation. The experiment is being tried out once more this year on these four acres. The plots are one-fifth of an acre in area and consist of eight plots of American Banner oats and eight plots of Red Fife wheat. The seed for this experiment is northern grown and is pedigreed seed.

No. 24—It is quite a problem to grow corn, even for ensilage, in Nevada. Late spring frosts force late spring planting, and early autumn frosts necessitate early cutting. We have planted No. 24 to nine of the hardiest varieties of Dent corn we could find, and the object is a comparative test as to earliness of maturity as well as to comparative yield. The corn is planted, six rows of each variety, in hills three feet apart each way. The varieties are as follows: Minnesota No. 13, Pride of Minnesota, Pride of the North, Sure Crop, Northwestern Dent, Minnesota King, Wisconsin Yellow Dent, Huron Dent, Improved Leaming.

No. 25—Here we have a duplication of varieties in No. 24, but we aim to be sparing in the matter of irrigation in this acre, with a view to a possible hastening of maturity and the production of more ears than generally falls to the lot of Nevada corn. This will embrace a comparison with No. 24 as to yield as well as to quality.

Fraction 2—This is a long narrow strip along the north fence and on this ground we have planted twenty strains of Soja beans. The question of the practicability of the manufacture of paint oil from this crop is a live one at present and by request we are trying out all available strains. Eighteen strains were sent us by a company interested in the matter; two were given us by Macdonald College, Quebec, Canada, as seed from the two best varieties grown there.

We have some odd areas, not numbered and not mentioned in the soiling experiment, and we might speak of these next.

(a) One and one-fifth acres south of the barn have been sown to Canada peas. It is the intention of the Animal Husbandry Department to conduct a test as to the value of these peas as a hog-finishing product. When the peas are about ripe the hogs will be turned into this plot and a definite test made as to gains made, comparative with some other regular method of fattening. Peas as a regular ration have won much favor in other States, and the results of this test should be of great interest to those of Nevada who grow their pork on alfalfa. It would seem that the discovery of some finishing ration that could be economically produced in Nevada is necessary if Nevada pork is to become a paying product for shipment.

(b) A somewhat irregular area of three acres, along the south fence, has been sown to Marquis wheat and Abundance oats. This area is newly planted pasture land and the object of the present crop is to secure clean seed for future experiments. The quality of the seed sown will be noticed in the following subdivision of the report.

Cooperative Experiments

This year we have several farmers cooperating with us in our variety tests. In this connection we have organized a tentative Experimental Union which we hope will grow in numbers and be the source of increased interest in the work of the Station. These farmers are trying out three varieties each of wheat, oats, barley, and peas, in plots of one-tenth acre in size. The Station is trying out the same varieties in duplicate. Folowing is a statement of the varieties now under test:

Wheat—Marquis, Red Fife, Defiance.

Oats—American Banner, Regenerated Abundance, Swedish Select.

Barley—Manchuria, Oderbrucker, New Zealand (2-rowed).

Peas—Golden Vine, Prussian Blue, Canadian Beauty.

The Marquis and Defiance wheats, Banner and Abundance oats and Manchuria barley came from Indian Head, Saskatchewan. The Marquis wheat is from the same stock that won two world's championships in the past two years. It is a dark amber, plump, and weighs 65 pounds to the bushel. The Red Fife is also an excellent sample. The Defiance was grown in the Dry Farm Station in Elko County and is from pedigreed stock. The Swedish Select oats and New Zealand barley comes from Montana Experiment Station. The Oderbrucker barley came from Wisconsin Station. The peas were grown by a specialist at Lindsay, Ontario, Canada. Every one of the twelve lots of seed is the product of years of selection, and our experimenters should grow something valuable from this seed.

The following are cooperating with us in the matter of these tests:

C. J. Henningsen, Gardnerville.
Andrew Martin, Reno.
Dr. P. B. Kennedy, Reno.
Charles Ross, Red Rock.
M. A. Laking, Reno.
H. J. Cazier, Wells.
J. H. Heward, Gerlach.
A. H. Sessions, Fort Bidwell, Cal.
C. L. Rowe, Lund.
H. F. Dangberg, Minden.
Modoc County Cooperative Association, Alturas, Cal.
Walfried Sohlman, Blaine.

Besides the tests embraced in this series we are having a number of other tests made by interested agriculturists:

(a) Charles Ross, Red Rock—Canada Yellow Flint corn.

(b) W. M. Snare, Reno—Canada Indian corn (the hardiest flint of which the writer knows) grown by the Indians north of Montreal before Jacques Cartier's time. This is a twelve-row variety, the result of selection by Professor Klinck of Macdonald College.

(c) Theodore Clark, Reno—Wisconsin No. 12 Dent corn; Compton's Early corn; field mangels, three varieties.

(d) Lloyd B. Patrick, Reno—Field roots, 6 varieties.

(e) C. J. Cazier, Wells—Hardy alfalfa, 5 strains.

(f) George Henningsen, Gardnerville—Hardy alfalfa, seed from selected individual plants.

(g) Nevada Land and Livestock Co., Deeth—Grass tests: (1) western rye, (2) timothy and alsike, (3) comparative treatments of river-bottom meadows; Golden Tankard mangels, a stock-feeding experiment.

It is but fair to say of our experimenters that they met us more than half way. No member was secured by soliciting; they were all volunteers.

Suggestions

1. The Station Farm is badly overrun with weeds. I would suggest that next year about one-half of the farm be treated to a course of alternate irrigation and cultivation to sprout and destroy the weed seeds. This could be done and it would pay well ultimately.

2. As soon as possible the removal of inside fences should be completed and the roads graded up and proper culverts installed.

3. A separator outfit is needed if the purity of seed stock is to be maintained.

4. While the Station Farm should not be a show place, it should be an inspiration to visitors. The aim should be to keep it a little neater than the average farm. Sufficient labor should be provided for this purpose. It must not be forgotten that the necessity for irrigation at this Station entails at least one-third more labor than falls to the lot of stations subject to sufficient rainfall.

5. Extension work is seriously needed to connect up the work of the Station with the efforts of the people of the State. The work we have just begun has demonstrated clearly to us that the people are ready and willing, but that geographically they are hard to reach.

Germination Tests

During the past year we have done considerable seed testing at this Station. Our germinator has a capacity of over eighty samples in duplicate. Seed placed between sheets of blotting paper was laid in this germinator and sprouts counted at four, seven, ten, and fourteen days. We offered to test free all samples sent in from the growers and dealers of the State, and many of these took advantage of the offer. When a purity test was desired the samples were passed on to the Station Botanist, who kindly cooperated with us in the matter of informing the people as to the nature of the seed we were sowing. Some particular experiments in germination were carried on by a senior student, Mr. Mortimer Charles, and the following is an extract from his report. Owing to lack of space the long detail of the tests has been omitted:

Seed testing to the farmer and the seed merchant is an extremely important matter. Its object is that of supplying information regarding the quality of the seed, respecting its purity and vitality. On the vitality depends much; many millions of dollars are lost annually in labor by the farmers who carelessly sow seed of poor vitality, or containing considerable foreign matter, or guilty of both faults.

There have been many tests made; tests are old, but they have been unsystematic, made in boxes and contrivances of all kinds. Systematic germination tests are comparatively new.

The public, growers and dealers, have not had the opportunity of free government or state tests, and especially is this so in the western country.

There are many problems in seed testing unsolved; the field is open for extensive work, almost unlimited. The attempt in this thesis is to solve a few of these problems, contained in the following experiments:

I. To ascertain comparative germination of olive and brown seeds of alfalfa.

II. To ascertain comparative germinating power of olive and green seeds of alfalfa.

III. A comparative pot test as to the strength of first month's growth of plants from (a) olive and brown, (b) olive and green seeds of alfalfa.

IV. To ascertain the most favorable temperature for germination of oats, wheat barley, alfalfa, and clover.

of time.

III. Within reason, temperature does not affect the percentage of germination. High temperature does favor the formation of molds; the spores are on the seed; their growth hinders germination; therefore the higher temperature does not suit old or damaged seed so well. Probably some kinds of seeds do best under rather cool conditions, while others act the opposite. About 20 degrees C. seems to suit most kinds of seed; this is about the ordinary house temperature.

IV. Seeds bought and sold in Nevada have a good deal to be desired. Our native seed germinated well; seed imported into Nevada is sometimes very poor. The Experiment Station, by offering to test seed for farmers, offers a protection that should be taken advantage of. Who for a difference of 20 cents per acre would take chances on the yield of a field?

V. Our tests in Division VI go to show that the frosted grain is low in germination, a d that it is an important matter to mature seeds without the injury by frost.

SOIL INVESTIGATIONS

As far as the writer is aware, this report initiates a new series here, and, since no precedent exists, he purposes to review and interpret the data obtained in considerable detail. In appreciation of the fact that the practical applications of results secured in scientific laboratories are of primary interest to the general agriculturist, he has endeavored to read into the discussions practical interpretations.

Owing to unavoidable delays, operations in this laboratory were postponed until December 30, 1912. The five and one-half months elapsing between that date and June 15, 1913, is the working period covered by this report. The data accumulated during this brief time must of necessity be meager and incomplete, and conclusions drawn therefrom venturesome and inadequate. Indeed, the author reserves the privilege of changing any expressed opinion if subsequent data indicates the contrary.

The aims of the soil laboratory have been two-fold. One object has been to meet the immediate demand for analytical soil work. A considerable number of soil samples have been received from farmers and prospective settlers. The examination of these samples has occupied the writer's attention at least 25 per cent of the time, and has led to soil knowledge of interest and value to farmers and to the State. The second purpose has been to pursue investigational work, pertinent to local problems, but primarily intended to advance the scope of knowledge concerning soils and their functions.

Since the work of this laboratory has developed into two separate lines, it seems advisable to outline the report pertaining thereto in two distinct divisions. The first division is devoted to the results and conclusions of the routine work, and popularly discusses Nevada soils in relation to fertility and crop production. The second part of this paper reports the status of the scientific investigations undertaken.

PART I

Soil Examination

The crop-producing power of a soil is the resultant of many forces; warmth, moisture, congenial physical condition, and available plant food are soil properties promoting superior plant growth. On the other hand, alkali salts, excess water, "baking" properties in clay soils, poor cultivation and lack of plant food seriously hinder the growth of plants. Other factors affecting the profit of the crop and consequently the value of the land are the source, quantity, and quality of irrigation water, the climate, length of growing season, and the distance to railroad transportation and markets. Before discrediting the soil the farmer should ascertain the facts concerning the quality of the seed used, the fitness of the variety for the climatic conditions, and make sure that weeds, fungi, and other pests are not extracting the profits. Thus many of the factors of crop production are purely local and can be best observed by the farmer on the ground.

Those factors of crop production relating to soils, either from a physical, chemical, or biological standpoint, are to be taken up in this laboratory. Up to this time little or no attention has been directed to the physical and biological characteristics of the soil samples sent in by farmers. This omission is due to the fact that our laboratory space, equipment, and assistance are not sufficient to allow of this work. On the other hand, some of the chemical features, as the quantity of plant food and the presence of alkali, are determined. The reports sent back to the farmer cover these points and general remarks are made as to the fitness of certain crops to the soil, and appropriate methods of cultivation and fertilization are discussed. These remarks will serve as an introduction to the following table, which takes up in detail the analyses of samples of soil sent in by farmers. As far as possible the soils have been arranged into groups representative of soil types or regional districts. A discussion follows the table:

TABLE I

Locality	Plant foods				Alkali salts		
	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Black alkali ($NaCO_3$)	Common salt ($NaCl$)	Glauber's salt (Na_2SO_4)
Humboldt Valley					2,400	6,400	
Humboldt Valley					800	5,600	3,600
Humboldt Valley	5,200		192,000	56,000	1,600	2,400	1,600
Humboldt Valley	3,200		100,000	28,000	1,200	1,200	4,800
Humboldt Valley	4,400		175,000	40,000	2,000	4,000	2,000
Ripley					400	11,200	40,000
Ripley					400	400	4,800
Smith Valley	3,600		46,800	28,000			
Smith Valley	4,800		60,000	19,600			
Tonopah	3,040	82,000	84,000				
Tonopah	2,320	82,400	76,000				
Smoky Valley	4,000	104,000	58,000	24,000	1,200		
Smoky Valley	4,000	116,000	55,000	20,000	1,600	400	
Smoky Valley	4,000	104,000	152,000	25,200	8,000	12,000	2,800
Smoky Valley	4,000	164,000	72,000	36,000	2,400	800	
Smoky Valley	3,200		80,800	30,400	3,200	400	
Pahrump Valley					600	4,800	2,000
Pahrump Valley					600	4,000	16,000
Pahrump Valley					1,000		2,800
Pahrump Valley					800	12,000	38,000
Stewart					28,000	43,200	52,000
Springdale					2,520	320	800
Beatty					12,800	2,400	
Beatty					12,800	4,400	
Pioneer	1,600	100,000	112,000	20,000	1,040	440	
Battle Mountain					400	22,800	
Battle Mountain					400	30,800	
Gardnerville	19,200	56,000	114,000	82,000	1,600	5,700	320
Goldfield	7,200	192,000	73,000	48,000	2,400	4,000	
Las Vegas					2,120	11,600	66,000
Las Vegas					1,800	31,200	138,000
Las Vegas					5,600	62,000	3,760
Las Vegas					3,200	14,400	62,800
Las Vegas					5,200	56,000	1,200
Las Vegas[a]			[b]56.67%	[b]15.27%			
Pyramid					2,000	23,200	3,300
Pyramid					2,000	4,800	400
Pyramid					2,500	25,000	5,600
Pyramid Lake Water (reported as lbs. per acre-ft. of water)					2,883	8,519	1,697
Carson Valley					1,200	900	
Carson Valley					1,200	700	
Carson Valley					1,300	1,700	
Carson Valley					1,100	700	
Carson Valley					1,600	450	
Carson Valley					3,200	2,500	
Carson Valley					2,200	450	
Carson Valley					2,500	1,100	
Carson Val. (surface scrapings)					28,000	2,500	
Carson Valley					800		
Carson Valley					1,600		
Locality unknown	4,800		90,000	88,000	43,200	132,000	3,200
Locality unknown	3,800	39,000	90,000				

[a]Sample of limestone from Las Vegas. [b]Calculated as $CaCO_3$ and $MgCO_3$

To date fifty-two samples of soils and water have been analyzed either for alkali salts or plant foods. Seven other samples have been received and reported upon without a chemical analysis. Four other samples have been sent in within the last day, bringing the total number to sixty-three for a period of five and a half months.

The greatest difficulty in drawing conclusions from these analyses lies in the uncertain and haphazard way in which they are often collected. However, a few facts of interest may be gleaned by a study of the figures given.

Plant Foods—Plants must have foods no less than animals. It is essential that certain elements be at their disposal in an available condition. Of these elements potassium, calcium, magnesium, iron, phos-

phorus, and sulphur are termed collectively the mineral requirements of plants and are derived solely from the soil. The soil also furnishes nitrogen to most plants excepting the legumes, but more concerning this a little later. As to the carbon, hydrogen, and oxygen of which plant tissues are largely constructed, it will suffice to say that these elements are secured from the air and soil moisture, and owing to natural cycles are abundantly supplied in the role of plant food. Still other elements are frequently taken up by plants, but, with the possible exception of chlorine, appear to be of no particular use to the plant.

The immediate agricultural practices have limited the demand and sale of plant-food elements to potassium, phosphorus, nitrogen, and occasionally calcium (lime). The fertilizer goods sold in the market are not elementary forms but various chemical combinations of plant foods and other substances. Undoubtedly the list of fertilizer materials will soon be extended in the future to include elements not actually used as plant food, but which indirectly seem to favor plant growth. Even now, advertisements of manganese in various forms as a fertilizer are appearing. Nevertheless our interest is chiefly concerned with potassium, phosphorus, calcium, and nitrogen.

These elements probably exist in the soil in three conditions—the reserve supply untouched by the immediate crop, the partially weathered state, useful to a certain extent, and the more highly soluble compounds which go to supply the crop's immediate demand for plant food. The line of demarcation between these divisions is not definite and they are adopted largely as explanatory measures. The total plant food is the entire quantity found in the soil irrespective of its availability.

The columns headed phosphorus, potassium, calcium and magnesium record the total amounts in pounds per acre-foot of these elements in some Nevada soils. (An acre-foot of sandy soil weighs about 4,000,000 pounds, loam soils 3,500,000, and clay soils 3,250,000 pounds.) The value of this method of expression is realized when it is known that a fifty-bushel crop of wheat removes 96 pounds of nitrogen, 16 pounds of phosphorus, and 58 pounds of potassium from the soil. To illustrate that different crops have different requirements, compare alfalfa, removing in an eight-ton crop, 400 pounds of nitrogen (to be discussed later) 36 pounds of phosphorus, and 192 pounds of potassium, with the food requirements of wheat. To be sure, these figures are based on large crops, improbable under many conditions, but by no means impossible.

Phosphorus commands a position second in importance to nitrogen in the practical economy of crop production. As to the supply of this element in Nevada soils, Table I indicates that there is an abundance. The least quantity contained in any of the soils examined is 1,600 pounds per acre-foot and the highest 19,200 pounds. Excluding these extremes the average is 4,070 pounds per acre-foot—sufficient to produce 254 fifty-bushel wheat crops, and 113 eight-ton alfalfa yields, provided the plants withdraw no phosphorus from the deeper strata of the soil.

It must be remembered that most of the phosphorus is in an insoluble form and of little use to plants. Indeed, only 1 per cent or less of the total phosphorus is likely to be available for plants. Each year the weathering processes, including the action of thermal changes, the solvent power of water, carbonated waters, and organic acids, and the indirect effects of biological agencies, liberate a small percentage of phosphorus, making it available to plants. Just how rapidly this takes place is not known,

but that the rate of change from the insoluble to the soluble may be extensively controlled by the farmer is a well-established fact. Good farming consist of regulating the soil functions so as to constantly supply plant food in appropriate amounts and without waste.

How is this accomplished? In the first place cultivation aerates the soil, brings about better conditions for oxidation and other bacterial process, and consequently hastens the step toward availability. Green cover-crops, barnyard manure, and similar organic matter, plowed into the average Nevada soil would react favorably in increasing the usable plant food at the disposal of the plant. Soil mulching, preventing evaporation and retaining the soil moisture, assists to convert the insoluble supply of plant food into forms suitable for the present crop. Irrigation has the same tendency. Lime and gypsum operate in the same manner; however, Nevada soils (from the few I have examined) are well stocked in calcium carbonate, and will need no applications of this material for some time. The use of gypsum, except to correct black alkali, should be limited to a few hundred pounds per acre, for it is a soil stimulant and is apt to free plant food more rapidly than the plant can utilize it. Thus by cultivation, irrigation, green cover-cropping, and liming (where necessary), the farmer is able to draw upon the storage reservoir of plant food as needed for crop production.

We hear a great deal about soils becoming worn out. In many cases the soils still have ample plant food, but in a condition unfit for assimilation. The soil needs no replenishing, but needs green cover-cropping and cultivation, to increase the rate of availability, liberating plant food from the reserve store in sufficient quantity each year to supply the crop's demand.

Averaging the column headed "potassium" we find that the Nevada soils examined contain 111,150 pounds of this element per acre-foot. If the crops secure their required quantity of this element from the first foot alone, there is an ample supply for 1,000 crops of wheat, or nearly 500 crops of alfalfa. The same argument may be applied to potassium as to phosphorus; the soil has an abundant supply locked up but ready to be unlocked by cultivation, green cover-cropping, and irrigation. A few of the soils built up by the residue left by decaying organic matter, as old peat or tule beds, may be deficient in potassium, but unfortunately no samples representative of this class of soils as found in Nevada have been submitted.

The supply of calcium averages 96,700 pounds per acre-foot in the soils examined—indeed, an enormous quantity capable of supplying the demands of crops for a longer period than either the phosphorus or potassium supply. In many of the soils a considerable quantity of the calcium exists as calcium carbonate or limestone, which speaks well for the fertility of Nevada soils. Perhaps soils of a low, marshy nature, instanced by many situations in Washoe Valley, could be converted from natural pastures into alfalfa fields through drainage and liming. Soils of this character are very apt to be acid, and the lime applied corrects this harmful condition.

Since crops require small amounts of magnesium, iron and sulphur, and since these elements are generally present in soils in relatively large quantities, they may be dismissed without further thought at this time.

The keynote to permanent and profitable agriculture in Nevada lies in building up the nitrogen content of its soils. As in most arid regions,

the level plains and wide valleys of this State, lying exposed to the brilliant sun, have become deficient in nitrogen and organic matter. Evidently those methods of farming which return nitrogen to the soil should be practiced. Green cover-crops should be grown where feasible. Alfalfa and legumes generally should be adopted as standard crops and should hold a prominent place in crop rotations. As far as possible it is advisable to produce live stock upon the farm and return the manure to the soil.

In my brief visits to the country I have observed large heaps of manure around the stock-feeding corrals wasting in the open. All of this should be conserved in proper composts or applied to the soil shortly after its production.

Alfalfa, cow peas, clovers, and other plants of the legume family are enabled through the activity of certain micro-organisms of obtaining a portion or perhaps all of their supply of nitrogen from the air. The importance of this is evident when it is realized that nitrogen is the most costly element of plant or animal foods, and to secure it from the inexhaustible store in the atmosphere is indeed a money-saving and conservative process. For this reason, other factors being equal, it is advisable to grow legumes as frequently as possible.

A word or two concerning legume inoculation might not be out of place here. Nevada is particularly fortunate in having a large number of species of legumes in its natural vegetation. This fact possibly accounts for the nodule-forming bacteria in soils not previously inoculated nor used for the production of the domesticated legumes. As to what extent the organisms of the natural legumes can thrive upon the tame varieties is not definitely known. However, where alfalfa or other leguminous crops fail to show the characteristic root nodules, inoculation should be practiced. Either obtain soil from a field known to contain the nodule organism and broadcast over the new field at the rate of 200 pounds per acre, or secure pure cultures of the appropriate bacteria from reliable dealers. The first method is apt to introduce weed seeds, animal and vegetable parasites and nonvirulent organisms. If the culture is secured from unreliable sources, or if the directions are not strictly adhered to, the second method may prove a failure.

There are organisms in the soil which are potential factors in supplying the plant with necessary food. Some of these are bacteria capable of adding nitrogen to the soil without growing upon the roots of plants. The two or three Nevada soils examined failed to show the presence of this beneficial microscopic resident of the soil. Other soils will be examined with respect to this feature in the near future. Bacterial processes in the soil are also responsible for nitrates, probably the form of nitrogen most readily taken up by plants. Bacteria play an essential part in preparing the mineral food for plants. On the whole, the bacterial flora of the soil may be regarded as a factor of crop production equally as important as the chemical or physical constitution of soils.

One feature of Nevada soils to which particular attention should be directed is the alkali content. A glance at the columns in Table I headed "Alkali" shows the presence of various amounts of these substances in almost all of the soils examined. A great many soils in Nevada, apparently of high fertility, are rendered sterile by this subtle foe of crop production. If a soil is impregnated to the extent of 4,000 pounds of black alkali to the acre-foot, 10,000 pounds of common salt, or 20,000 to 30,000

pounds, or even more, of sodium sulphate, crop production is very apt to be unprofitable. Soils containing black alkali can often be remedied by applications of gypsum. However, drainage is the ultimate means of reclamation, if the salts are present in excessive quantities. The so-called principles of dry farming should be closely followed under any circumstances, but particularly if alkali salts are present. Mulching, surface cultivation, and shading, preventing surface evaporation and consequent accumulation of alkali salts upon the surface, are practices quite essential to follow in handling lands known to be impregnated with alkali.

As to the physical properties of Nevada soils, it may be said that they are generally in good workable condition. Those in the open valleys are inclined to be sandy with an admixture of river silt, and will be largely benefited by plowing under green cover-crops, the organic matter of which will greatly increase the water-holding capacity of the soil. The matter of green cover-cropping deserves thorough investigation, first, to determine the better crops to use, and, second, to obtain the desirable and necessary information regarding the decomposition of the organic matter in relation to the water supply. This latter thought is particularly pertinent to the so-called dry farming.

As to a general résumé, it may be said that Nevada soils are intrinsically rich in mineral plant food, and naturally deficient in nitrogen. Doubtless this condition is the result of the natural forces responsible for the formation of these soils and the environment under which they have existed.

By increasing the store of nitrogen through legume cropping or applications of nitrogenous fertilizers, a soil well balanced with respect to plant foods will result. With this in view Nevada soils will undoubtedly prove a wealth of productiveness.

PART II

Investigations Looking to Soil Improvement

As previously mentioned the lack of nitrogen in soils is often the chief limiting factor in crop production. This seems particularly true of the arid regions of the world. Consequently any information relating to nitrogen and its accumulations in soils, and pertaining to any means of obtaining this element in forms suitable for agriculture, from the abundant supply in the atmosphere, seems to be desirable. Upon the appearance of Headden and Sackett's papers describing and discussing the nitrate accumulations in certain Colorado soils, it occurred to the writer that if the natural biological agencies at work in these instances might be controlled, it might possibly lead to methods of fixing nitrogen for commercial purposes from the air. (I might say that I do not agree with all the views stated in the above papers, but accept the facts as presented and assume for sake of further experiment that the nitrates are actually the results of bacterial fixation of nitrogen—an explanation brought forward, but, to my mind, unproven as yet.) Accordingly "The Biological Fixation of Nitrogen for Agricultural Purposes" was presented as Project No. 1 under the Adams Fund, and which met the approval of the Director of the Office of Experiment Stations, February 17, 1913.

BIOLOGICAL FIXATION OF NITROGEN

Work upon this project has progressed slowly. Our equipment does not permit of the nitrogen determinations so essential, and the lack of a

pressure filter pump is deplorable. At the time of proposing this project, the use of specially designed apparatus in which to cultivate the organisms was contemplated, but we have been unable to obtain this apparatus.

The first experimental series under this project were carried out in liquid cultures in 250 cc. Erlenmeyer flasks; 50 cc. of a 2% mannite solution, containing in addition 0.2 gm. K_2HPO_4, 0.2 gm. $MgSO_4$, .02 gm. $CaCl_2$, and one drop of a 10% solution of Fe_2Cl_6 were placed in the flasks and sterilized. These were then inoculated with pure cultures of Azotobacter organisms, kindly sent me by Professor Sackett of the University of Colorado. A week or ten days later each of the flasks was inoculated with a pure culture of an ammonifying organism and a comparatively pure culture of nitrifying organisms[1]. After the lapse of a month or more, qualitative tests proved the presence of nitrates in some of the flasks. Upon the addition of a small quantity of $CaCO_3$ to the flasks, the nitrate content seemed to increase. With this work as a crude preliminary experiment other series were started. Sand washed free from dust with tap water was then employed as a medium in which to grow the organisms. One hundred grams of this sand was weighed into tumblers and a gram of $CaCO_3$ added to each tumbler and the whole sterilized; 15 cc. of sterile mannite solution was then introduced. The sand was then inoculated with pure culture Azotobacter organisms. A week later ammonifying and nitrifying organisms were also added. The tumblers were incubated at 30°C. for thirty-two days, meanwhile maintaining the water content of the soil constant by additions of sterile distilled water every five days. At the end of this time the nitrate content of the sand was determined.

The results of this series would lead one to believe that nitrogen fixation, ammonification, and nitrification could not proceed in the usual order upon an identical atom of nitrogen. Two different Azotobacter organisms, and four different species of ammonifying organisms, as well as the nitrifying organisms, were tried in various combinations. No more than one species of each type of organism was introduced into a single tumbler. It might be added that the nitrifying organisms were obtained in a comparatively pure condition by transferring several times into inorganic media. One set of duplicates gave positive qualitative tests for nitrates with diphenylamine and sulphuric acid and traces with the phenoldisulphonic acid method. In these particular tumblers a nonpigment-producing Azotobacter organism, Bacillus coli, and the nitrifying organism were present. These bacteria were added by means of suspensions in water, thus avoiding the error of introducing sufficient organic matter to vitiate the results. Though the findings of this series did not corroborate the original theory, yet traces of nitrates were found in tumblers which had been inoculated with Azotobacter No. 1, Bacillus coli, and the nitrifying organisms. This gives evidence that if the proper combination of organisms and stimuli be present, considerable quantities of nitrates might be recovered from the media.

A third series was undertaken in which sterile soil containing 2% of mannite and 2% of $CaCO_3$ was used as the medium of growth. Unfortunately the total nitrogen could not be ascertained in this experiment

[1]The writer is indebted to Professor Peter Frandsen of this University for the pure cultures of ammonifying bacteria used in these experiments. *Bacillus Niger* is a new species of bacteria isolated and named in Professor Frandsen's laboratory.

either before or after the nitrates were determined, consequently the data presented is solely in reference to nitrates and appears in Table II:

TABLE II

Soil	Mannite	Calcium carbonate	Inoculation[1]	Nitrates
100 gr.	2 gr.	2 gr.	Azoto. No. 1—B. pyocyaneus	.60 mg.
100 gr.	2 gr.	2 gr.	Azoto. No. 1—B. niger	Trace
100 gr.	2 gr.	2 gr.	Azoto. No. 2—B. pyocyaneus	1.35 mg.
100 gr.	2 gr.	2 gr.	Azoto. No. 2—B. niger	.66 mg.
100 gr. (sterile blank)				.63 mg.

[1] In addition to the organisms mentioned above, nitrifying bacteria were also introduced into the soil in all the tumblers.

We can draw no conclusions relative to nitrogen fixation and subsequent alteration into nitrates from this series. We can, however, see the immense advantages of having pure cultures of the proper type in the soil, for the second combination seems to remove all the nitrates, while the third combination doubles the nitrate content of the soil. The additional nitrates may have been derived from the organic matter of the soil or may be the result of subsequent ammonification and nitrification of Azotobacter cells, but this is pure speculation. This series indicates the possibilities of soil sterilization and inoculation.

A fourth series carried on in Erlenmeyer flasks containing sand and mannite gave evidence that the ammonifying and nitrifying organisms could remain alive in the media suitable for Azotobacter development and which contained Azotobacter cells and their life products. The two Azotobacter species were employed in various single combinations with Bacillus proteus vulgaris, B. niger, B. pyocyaneus, B. subtilis and an ammonifying organism No. 11 secured from hot-house soil. In addition to these organisms, nitrifying bacteria were also included. Sterile tubes of peptone and NH_4SO_4 solutions were inoculated from the flasks after thirty days' incubation. In the course of a few days the peptone tubes all showed the presence of the characteristic ammonifying organism used. The NH_4SO_4 was oxidized to nitrates in all but two tubes. This at once indicates the peculiar relationship between species of bacteria. Apparently nitrifying organisms could not live in the presence of Azotobacter No. 2 and Bacillus pyocyaneus or B. proteus vulgaris, yet they lived in combinations of the latter with Azotobacter No. 1. Possibly one species of bacteria may be excluded from the media by toxic substances formed in the process of metabolism of other organisms. Only in one flask and its duplicate are nitrates formed, and in that case the nitrifying organisms were absent.

The evidence at hand does not warrant definite conclusions, but on the whole is rather favorable to the explanation of the accumulation of nitrates in Colorado soils, as offered by Headden and Sackett. Though only in a few instances are nitrates formed, yet surely from the innumerable combinations possible of the various organisms which are concerned in the processes of nitrogen fixation, ammonification and nitrification, one or more combinations will surely yield nitrates. Our object is to find organisms capable of growing together, and which produce sufficient nitrates to be of consequence. In addition to the above-mentioned types of organisms, it will be essential to introduce algæ to furnish the energy

necessary for the fixation of nitrogen. It may be necessary to employ some agent, either chemical or biological, to destroy the Azotobacter cells as rapidly as they begin to deteriorate. This factor must be of a peculiar nature, active only toward old disintegrated cells of Azotobacter, harmless to the young thriving cells, and neutral or stimulative toward the ammonifying and nitrifying organisms. This work should be continued under a variety of conditions. Though it should answer the original query in the negative, yet it leads into the important field of pure cultures in relation to soil fertility.

BACTERIA IN SOILS AFFECTED BY IRRIGATION

Project 2, entitled "A Study of the Bacterial Flora and Activity in Soils as Affected by Irrigation," was approved at the same time as Project 1. The studies contemplated under Project 2, including tumbler, pot, and field experiments, are of particular interest and application to this State where irrigation is practiced so widely.

That plants are apt to turn yellow and lose their vigor if too much water is applied to the surface of the soil is a matter of common observation. We have noticed this yellowing particularly in the case of Lima beans and allied legumes. It rarely seems to occur except where thin layers of water cover the soil for several days or fine silt is deposited over the entire surface. Often the yellow color and sickly condition persists through the entire season, though no further irrigation may be practiced, and the soil becomes sufficiently dry to warrant the plant's recovery, if the diseased condition is due to the direct effects of a temporary submergence. That alterations in the bacterial flora and activity may be responsible for the unfavorable conditions existing under the circumstances mentioned, is a possibility worthy of consideration. It appears of particular interest in this connection to observe acid production as well as nitrogen fixation, ammonification and nitrification as affected by the various modes of irrigation.

The work up to date on this problem has been carried out in soils in tumblers, and the results relative to acid production obtained have been unsatisfactory, owing largely to the discrepancy between duplicates. The source of error lies in the difficulty of obtaining clear filtrates of water extractions of the soils of this region. The fine silts and organic and clay colloids prohibit the use of the usual paper filters for clearing the solution. A pressure filter pump equipped with Pasteur filters would overcome this difficulty. However, the few approximate results secured indicate that soils supplied with excess moisture (judged by the physical conditions of the soil, and in this case about 27 per cent upon an air-dry basis) rapidly became acid if fertilized with dried blood. Surprisingly enough, soils treated with dextrose, instead of blood, showed but very little acid after three weeks' incubation at 30°C., even with 30 per cent of water. With a filter pump and a few of the details worked out, this work could be prosecuted with considerable rapidity.

Since the soil used in these experiments was obtained from the University farm, it seems of interest to add the results of experiments illustrating the optimum moisture condition for ammonification and nitrification. One hundred grams of air-dried soil was weighed into tumblers and 2 grams of blood added. Various percentages of sterile water were added, the mass thoroughly stirred and incubated at 30°C.

for four days in the case of ammonification, and for three weeks where nitrification was the object. Ammonia was determined by direct distillation from the soil with magnesia, catching the ammonia in standard acid and titrating the excess acid with N-10 ammonia. The nitrates were determined in the soil extract by means of the phenoldisulphonic acid method. The results appear in the following table:

TABLE III

No.	Water, per cent	N-10 ammonia produced	Nitrates formed
1	16	56.85	.0094 mgs.
2	19	61.80	.0096 mgs.
3	22	67.20	.0071 mgs.
4	25	70.70	.0037 mgs.
5	28	63.00	.0020 mgs.

From this table it is quite evident that a water content most suitable for ammonification is not the optimum condition for nitrification. Ammonification proceeds most rapidly at the water content of 25%, and is not markedly affected by differences of 3% in water. On the other hand 19% of water is most advantageous for nitrification, and the rate of nitrification decreases over 50% as the water content increases to 25%. From these figures it is probable that 18% to 20% of water is the most suitable water content for this soil, at least for the bacterial processes taking place in it.

Colloids as Protective Substances for Bacteria

This problem was undertaken independent of special funds, and received considerable attention owing to the fact that the laboratory equipment was better adapted to its prosecution than to the work involved in the Adams Fund projects.

Some previous work relative to the absorption of nitrates by colloidal materials led the author to think that colloids, by absorbing toxic substances and removing them from the sphere of action, might possibly prove protective toward living organisms. It was thought at the time that introducing colloids into soils impregnated with toxic alkali salts might alleviate the condition sufficiently to permit of bacterial action and plant growth.

Up to the present time only $Al_2(OH)_3$ and $Fe_2(OH)_3$ have been employed as colloids. However, it is the intention to use organic as well as inorganic colloids as the work progresses. The aluminum hydrate was precipitated by NH_4OH from a solution of potassium alum, and then washed with hot water forty or fifty times, or until practically free of sulphates and ammonia. The mass of precipitate was then transferred to a bottle and water added until a suspension capable of being handled with a pipette resulted.

The first experiment was carried out in a solution of peptone in 250 cc. Erlenmeyer flasks. To these flasks various amounts of a salt solution were added introducing the toxic element. A known amount of $Al_2(OH_3)$ suspension was added to half the flasks by means of a pipette. Sufficient distilled water was also added to the flasks to make the volume equal in all cases. The flasks were then sterilized, cooled, and inoculated with 5 cc. of a soil infusion. After four days' incubation the ammonia formed was distilled off, caught and titrated in the usual manner. The results are given in Table IV, and represent the averages of duplicate series which gave concordant results:

TABLE IV

No.	Media	Salt	$Al_2(OH)_3$	A N-10 ammonia (ammonia produced)	B Ammonia produced
1	50 cc. of 2% peptone	0	14.75 grs.	52.90	50.55
2	50 cc. of 2% peptone	[a]1	14.75 grs.	52.65	52.10
3	50 cc. of 2% peptone	3	14.75 grs.	52.45	51.30
4	50 cc. of 2% peptone	6	14.75 grs.	53.75	49.10
5	50 cc. of 2% peptone	10	14.75 grs.	47.50	47.20
6	50 cc. of 2% peptone	15	14.75 grs.	45.10	40.25
7	50 cc. of 2% peptone	20	14.75 grs.	43.55	28.90
8	50 cc. of 2% peptone	25	14.75 grs.	30.75	23.00
9	50 cc. of 2% peptone	30	14.75 grs.	19.65	25.40

[a]CC. of bimolecular NaCl solution.

In column A the figures presented represent the N-10 normal ammonia produced by the organisms in the presence of 14.75 grams (wet weight) of $Al_2(OH)_3$. The results in column B were obtained from a series of flasks from which the $Al_2(OH)_3$ was omitted, but which were exactly similar in all other respects to the flasks giving column A. Upon comparing the two columns it will be observed that they are practically similar within the limits of error down to No. 6, containing 15 cc. of a bimolecular NaCl solution. At this point the organisms formed 5 cc. more of ammonia in the flask containing $Al_2(OH)_3$ than in the flask not containing it. In flask No. 7 we see a still wider difference amounting to 14.65 cc. of N-10 NH_4OH_7, or the organisms prospered 33⅓% better in the presence of $Al_2(OH)_3$ than in its absence. With 25 cc. of the salt solution (see No. 8) the $Al_2(OH)_3$ still seemed to exert a beneficial influence in behalf of the organisms. With still more salt, however, the flasks containing the $Al_2(OH)_3$ were less favorable. I might add that 14.75 grams of $Al_2(OH)_3$ in the wet colloid state actually carried .623 grams of $Al_2(OH)_3$.

A second series, substituting Na_2SO_4 for NaCl was also run, with the following results:

TABLE V

No.	Media	Salt	$Al_2(OH)_3$	A N-10 NH_4OH produced	B N-10 NH_4OH produced
1	50 cc. of 2% peptone	0	20 cc.	48.95	46.40
2	50 cc. of 2% peptone	[a]5	20 cc.	50.90	48.25
3	50 cc. of 2% peptone	10	20 cc.	48.25	38.30
4	50 cc. of 2% peptone	15	20 cc.	45.25	36.05
5	50 cc. of 2% peptone	20	20 cc.	27.50	24.85
6	50 cc. of 2% peptone	25	20 cc.	27.95	24.70
7	50 cc. of 2% peptone	30	20 cc.	18.20	22.50

[a]CC. of a bimolecular Na_2SO_4 solution.

In this case the $Al_2(OH)_3$ was added from a suspension by means of a pipette and 20 cc. of the suspension contained .380 grams of $Al_2(OH)_3$.

A study of this table reveals about the same condition as existed in the NaCl series. It is certain that $Al_2(OH)_3$ renders NaCl and Na_2SO_4 in solution at certain concentrations less toxic.

As to the mechanics of the protective action, I am inclined to believe that these salts are absorbed or adsorbed by the colloid and that in this state they are less injurious. I do not consider $Al_2(OH)_3$ in the light of a stimulant, for the mere presence of that body seems to have little or no effect when an infusion containing a large variety of organisms is used as an inoculum.

Other possible conditions, as increased surface, the absorption of food or toxic metabolic products, or the presence of soluble aluminum in some form, might have some influence upon the activity of the organisms, but the data at hand justifies no definite conclusions.

This protective action of colloids seems of considerable significance in relation to alkali soils. Soils containing large quantities of organic matter, more or less colloidal in nature, should present a more congenial habitat for organisms than a soil with less colloidal matter, though the soils be impregnated equally with alkali. The more favorable condition in this case omits reference to increased food supply, better temperature and moisture conditions, and the other considerations all potent in facilitating bacterial action, but adds another factor, the absorption of harmful substances, which brings about an improved environment.

The effect of $Al_2(OH)_3$ in combination with common salt upon pure cultures of ammonifying organisms was also studied. These experiments were carried out in the same manner as the two series previously discussed. Strikingly enough, the $Al_2(OH)_3$ proved to be toxic to the organisms in pure culture, and little or no ammonia was produced even when the flasks contained as low as .380 grams of $Al_2(OH)_3$. Mixed cultures are evidently enabled to withstand adverse conditions, at least in this instance, much better than pure cultures. Perhaps a single organism in the mixture was highly resistant toward $Al_2(OH)_3$ and accomplished the ammonification measured. However, I am inclined to favor the idea that the life products of some of the organisms either tend to keep the aluminum precipitated or render it harmless through other chemical reactions. Neither Bacillus pyocyaneus or B. niger were capable of producing more than traces of ammonia from peptone in the presence of $Al_2(OH)_3$.

A colloidal preparation of starch was also employed as a possible means of overcoming the toxic properties of salts in solutions. No very promising results, either negative or positive, have been secured. It must be remembered that only those organisms which do not produce starch-liquifying enzymes are properly eligible for this test. Bacillus pyocyaneus belongs to this class and will be worked with in the near future. Starch in colloidal condition seems to lower the ammonifying power of organisms. There is no sudden drop in the efficiency of the organisms as is often shown when toxic substances are added to the media, but a mild and constant suppression is exhibited. Eight pure cultures of ammonifying organisms lost from 0 to 50% of their physiological efficiency, when 25 cc. of a 5% starch solution were added to 25 cc. of a 2% peptone solution as a medium, as is shown in the following table:

TABLE VI

No.	Organism	A N-10 NH_4OH produced	B N-10 NH_4OH produced
2	B. fluorescens	9.00	8.85
3	B. proteus vulgaris	13.80	12.80
4	B. niger	16.62	12.05
5	B. coli	10.02	9.70
6	B. prodigiosus	7.92	7.30
8	B. pyocaneus	16.90	14.10
10	B. subtilis	16.25	7.70
11	Garden soil No. 2	15.05	15.50

Column A gives the ammonia produced in the absence of starch; Column B in the presence of starch.

The introduction of $Al_2(OH)_3$ to soils in tumblers causes the same slight depression in ammonification power as observed when starch is added to liquid culture media. The ammonifying soil flora is about 87% as efficient in the presence of .5 gram of $Al_2(OH)_3$ as when that substance is absent. Varying amounts of salts or water seem to have little or no influence on the above-mentioned figure. One set containing $Fe_2(OH)_3$ gave practically the same results as were found when $Al_2(OH)_3$ was used. The writer is of the opinion that the colloids used have no particular toxic reaction upon the bacteria (in mixed culture), but that some undetermined factor, as the absorption of ammonifiable nitrogen, diminishing the quantity of ammonia possible to be produced seemingly decreases the physiological efficiency of the soil flora. The difference in the physical condition of the soil treated with $Al_2(OH)_3$ was easily distinguished. The physical differences in relation to water supply were lessened by using different quantities of water and thereby establishing optimum moisture conditions for the untreated soil and for soil containing $Al_2(OH)_3$.

One series of tumblers was devoted to the effect of $Al_2(OH)_3$ on nitrification as a soil function. Since the increase of colloids in the soil decreases the available water, assuming the water content of the soil to remain fixed, and since nitrifying organisms are sensitive to the supply of moisture, it was deemed best to determine the optimum water condition for nitrification in soils free of $Al_2(OH)_3$ and those to which the colloid had been added. The details and results of the experiment are given in the following table:

TABLE VII

No.	Soil	Blood	$Al_2(OH)_3$	H_2O	Mg. of N as nitrates
0 (ster.)	.009	29	25 cc.	0	1.2
1	.009	29	19 cc.	0	11.1
2	.009	29	19 cc.	3	13.3
3	.009	29	25 cc.	10	8.3
4	.009	29	25 cc.	3	4.8
5	.009	29	25 cc.	6	3.9
6	.009	29	25 cc.	9	1.6
7	.009	29	25 cc.	12	.7
21	.009	29	10 cc.	16	9.4
22	.009	29	10 cc.	19	9.6
23	.009	29	10 cc.	22	7.1
24	.009	29	10 cc.	25	3.7
25	.009	29	10 cc.	28	2.0

The examination of this table reveals some very interesting data. In the first place $Al_2(OH)_3$ acts in some manner as a stimulant. Perhaps some aluminum ions go into solution in the organic acids, and react favorably upon the nitrifying organism, or the OH ions may perform the function of neutralizing organic acids, thus eliminating this undesirable factor. The highest production of nitrates is noted when 19 cc. of the colloidal suspension and 3 cc. of sterile distilled water are added to 100 grams of soil containing 2 grams of blood. Thus this tumbler held nearly 22 cc. of water, and yielded 13.3 mgs. of nitrogen as nitrates. When the soil was watered with 22 cc. of sterile distilled water the production of nitrogen as nitrates was only 7.1 mgs. The optimum moisture condition in the soil alone for nitrification appears to be about 19%, with a formation of 9.6 mgs. of nitrogen as nitrates. With 19 cc. of colloidal suspension 11.1 mgs. of nitrogen as nitrates were recovered. Evidently a stimulation occurs.

The addition of colloidal matter increases the percentage of moisture required to bring about optimum conditions. On the other hand, nitrification proceeds more advantageously where excessive moisture obtains, if the colloid is present; for instance, 28% of water in the soil practically inhibits nitrification, reducing the nitrogen found as nitrates to 2.0 mgs., while 4.8 mgs. are found where 28 cc. of water including .5 gram of $Al_2(OH)_3$ are added to the soil, and 3.9 mgs. are produced even when 31 cc. of water and the colloid is present. These effects are primarily physical, due to the increased surface brought about by the colloid. Perhaps this circumstance may be responsible for the apparent stimulation already noted. It is also quite likely that the oxidizing power of the soil exclusive of the nitrifying organisms is benefited by increased interior surface.

The study of colloids of all types in soils relative to the various chemical and physical reactions upon living organisms of the plant world should be continued, for it leads to a wider knowledge of the functions and behavior of soils under various conditions.

DEPARTMENT OF ANIMAL HUSBANDRY

Comparison of Alfalfa Hay and Alfalfa Silage as a Feed for Dairy Cows

In this experiment it was planned to use four cows, two fed on alfalfa hay as a roughage and two fed on alfalfa silage as a roughage, the grain ration being the same in both cases. The grain ration consisted of ground corn and oats in equal parts and one part of oil meal to every ten parts of corn and oats. The experiment was started on February 3, 1913, with two cows, No. 1 and No. 2, fed on silage, and No. 3 and No. 4 on hay. The respective weights were as follows:

No. 1, 1,370 lbs.; No. 2, 1,000 lbs.; No. 3, 1,005 lbs.; No. 4, 1,100 lbs.

During the first week cows Nos. 1 and 2 became very restless, breaking out of the corral several times and eating anything they could get in the shape of dry roughage. They finally refused to eat the silage, and at the end of the week the following change was made: Cows No. 1 and No. 2 were fed hay, and cows No. 3 and No. 4 were fed both hay and silage. It had been noticed that when all of the cows were being fed on mixed roughage that an increase in the amount of alfalfa silage and corresponding decrease in the amount of hay seemed to cause a slight constipation, which was considered peculiar inasmuch as the silage furnished more succulence, but when the hay was entirely removed the opposite condition obtained, making it necessary to change the form of feed for these cows.

The effect upon the milk flow and fat production was as one would expect when the digestive organs are out of order. There was a decrease in the amount of milk and slightly abnormal percentage of fat, making an increase in the total amount of fat over that of the preceding week. The two cows fed on hay alone made no variation greater than usually occurs from week to week. The following table shows the results during the first six weeks of the experiment after the change of feed had been made:

No. of cow	Weight at beginning—Pounds	Weight at end	Total hay fed—Pounds	Total silage fed—Pounds	Total grain fed—Pounds	Estimated cost of feed	Production of milk	Amount of fat	Increase	Profit
1	1,375	1,435	804	....	392	$10.96	1,150.7	40.32	13.97	$3.01
2	1,000	1,015	734	....	389	10.55	1,452.9	40.68	14.11	3.56
3	1,005	1,095	490	812	414	11.83	1,292.5	41.76	14.50	2.77
4	1,100	1,175	562	840	420	12.37	1,922.6	51.31	17.60	5.23

As is seen in the first table, all of the cows gained in weight. No. 1, being well advanced in lactation, gained more than the others and also lost in production at the end of the period. The slight decrease in the production of Nos. 3 and 4 (No. 3, 1.44 pounds of fat per week; No. 4, .74 pound of fat per week) might easily be attributed to advancement in lactation period, but, from the fact that No. 2 gained slightly (.15 pound per week), it would be fair to conclude that the alfalfa silage has no beneficial effect on milk production. A single experiment being insufficient to prove such a point, it is planned to repeat several times for verification.

A Study of the Development of Beef and Dairy Cattle with Reference to Feed, Form, and Function

This experiment was begun January 13, 1913. In conducting this investigation the plan was to measure the animals each month and keep an account of the feed consumed. At the beginning all of the calves in the University herd were included, but, on account of sales and losses, only four animals were retained—one Holstein-Friesian bull, one Holstein-Friesian heifer, one Aberdeen Angus steer, and one Hereford heifer.

The following forms will show how the data is kept:

FORM I

Amount of whole milk,	....
Amount of skim milk,	....
Grain,	....
Alfalfa hay,	....
Silage,	....
Roots,	....
Remarks,	....

FORM II—MEASUREMENTS TAKEN

	Date	*Date*	*Date*
Weight,	....	....	....
Length of rump,	....	....	....
Length of back,	....	....	....
Length of neck,	....	....	....
Length of head,	....	....	....
Width of head,	....	....	....
Width of hips,	....	....	....
Width between pins,	....	....	....
Height of chest,	....	....	....
Height of withers,	....	....	....
Height of hip bones,	....	....	....
Height of pin bones,	....	....	....
Girth at heart,	....	....	....
Girth at middle,	....	....	....
Girth at flank,	....	....	....

These measurements are recorded each month, and it is planned to continue the work until the animals are mature, adding new animals to the list each year. As yet no conclusions can be drawn, as the work has not proceeded far enough.

A Comparison of Various Soilage Crops as a Substitute for Pasture for Dairy Cows

This experiment is being carried on jointly by the Departments of Agronomy and Animal Husbandry at the University Farm. The Agronomy Department is to furnish green feed in season, beginning with rye and vetch, followed by alfalfa, oats, and peas, second-crop alfalfa, corn, and third-crop alfalfa in rotation, or changed in such a way as to continually use green feed. The Animal Husbandry Department is to feed the cows, keep account of the weights of feed and of the animals, and the value of the product.

This experiment being in progress at the present time shows no results other than the fact that the cows keep up well on rye and vetch, both in flesh and milk production.

Exhibits

The College of Agriculture of the University of Nevada was represented at the California State Fair, 1912, very creditably, showing Herefords, Holstein-Friesians, Aberdeen Angus, and Jerseys in cattle; Berkshire hogs, and Merinos, Southdowns, Shropshires, Dorsets, and Hampshires in sheep. Premiums to the amount of almost $900 were carried away.

Judging Team

A judging team composed of students from the classes in Animal Husbandry was in attendance at the International Livestock Exposition at Chicago, November, 1912.

DEPARTMENT OF BOTANY, HORTICULTURE AND FORESTRY

P. B. KENNEDY
A. A. HELLER

The following lines of investigations have been carried on: Moisture conditions on irrigated and nonirrigated acres of apple orchard on the Station Farm; late or long period blossoming of varieties of apples to escape spring frosts; frost-fighting investigations; a new disease of Carolina poplar; vegetable growing; native vegetation as an indicator of soil conditions; the flora of the State; clover investigations under the Adams Fund; a study of our native poplars and coniferous trees by Dr. A. A. Heller; investigations of wormwood and Indian hemp as plants worthy of introduction into the State; eradication of weeds.

Irrigated and Nonirrigated Areas of Apple Orchard

The trees were planted on both acres in the spring of 1903. The third spring (1905) no further irrigation was given to one acre, while the other received a thorough irrigation once a month. The former we have termed the dry-land acre, and the latter the irrigated acre, for convenience.

The dry-land acre has been kept in perfect tilth with a mulch of about six inches of loose soil, while the irrigated acre was cultivated after each irrigation.

No difference has been detected in the growth of the trees or the production of blossoms or fruit on either of the acres for the last six years.

In the fall of 1912 a hole six feet square and fifteen feet deep was dug directly in the center of each acre to determine the character and condition of the soil in the two acres. The soil has been generally termed a silt loam by Mr. L. T. Sharp of the Department of Soils. It has its origin in the old lake deposits and the difference in the character of the soil at the different depths is due to the different strata encountered.

The conditions in the dry-land acre were as follows:

First foot—Fine loose silt loam, very dry.

Second foot—Firm silt loam, compacted, very dry.

Third foot—Hard silt loam, compacted, slightly moist.

Fourth foot—Same.

Fifth foot—Same.

Sixth foot—Soil less compacted, slightly moist.

Seventh foot—Soil more sandy with a few small rocks, slightly moist, darker in color.

Eighth foot—Soil containing gravel, dark in color, stiff and hard, more moisture.

Ninth foot—Moisture increasing, soil more loose with fewer rocks and gravel.

From the tenth to the fourteenth foot strata of gravel of different degrees of fineness were passed through, while at the fifteenth we came to pure gravel and large round boulders. Here the conditions were wet, but no standing water.

The conditions in the irrigated acre were similar as regards the character of the soil, but the moisture conditions had changed its

texture to a considerable extent. The silt loam in the second, third, fourth, fifth, and sixth foot in the dry-land acre was very hard and dry, while in the irrigated acre it was moist and easily shoveled out without the aid of a pick. The workman made the remark that it was fine for potatoes.

In spite of the conditions of moisture and texture of soil as above noted, the trees in both acres seem to have grown equally well.

Both holes remained practically dry throughout the winter.

In order to find out what difference the treatment of the two acres had on the development and direction of the roots, a deep ditch two feet wide and fifteen feet long was dug out alongside of a tree in each acre, thus severing half of the root system.

The roots in the irrigated acre had a tendency to remain nearer the surface than those in the dry-land acre. There was not much difference in this respect, however, as would be expected. The roots of the tree on the dry-land acre spread wider and deeper seeking for moisture.

An interesting feature was the development of numerous clusters of small fine roots attached directly to the main trunk of the tree and from three to six inches below the surface of the ground. These were present on the trees on both acres, but were more abundant on the dry-land acre.

During the winter a fall of snow occurred while the ground was dry as powder. An examination after the snow disappeared revealed the fact that the snow had only moistened the ground to a depth of two inches. The snow had for the most part evaporated into the air. Just exactly what part these small roots play in the supplying of moisture and food material to the tree we are unable to state.

We are of the opinion that the trees on the dry-land acre are being watered by subirrigation through capillary action of the soil from underground water derived from irrigation ditches and lands above, and that the cultivation has had little to do with the conservation of moisture secured from rains or snow.

The water level is known to come within six feet of the surface on similar land about 200 yards distant during the middle of summer, which is the height of the irrigation season.

By watching the rise of the water in the fifteen-foot holes now in the orchard we will be able to determine this exactly. The roots of the tree on the dry-land acre extended to a depth of ten feet, while very few on the tree on the irrigated acre extended to a depth of eight feet.

We believe from the observations that, on much of the land in the Truckee Valley where there is deep soil and no hardpan, apple trees after the first few years will grow successfully without irrigation.

Blossoming of Apple Trees

The time of blossoming of a variety of apple has an important bearing on the prospects of its producing fruit in this climate. The Station orchard, which contains many varieties, began to blossom this year on April 6 and continued to blossom until the 1st of June. On account of the large number of severe frosts which occur during the month of April, we consider that all early blossoming varieties should not be planted. Even if a variety begins to blossom the last week in April or the first week in May, the orchardist will usually have six or more frosts to contend with.

Some of the most suitable varieties for planting are Yellow Transparent,

Early Harvest, Wealthy, Maiden Blush, Rome Beauty, Jonathan, York Imperial, Rhode Island Greening, Gano, Black Ben, Ben Davis, Geniton.

Frost-Fighting Investigations

The orchard was in bloom this year from April 6 to June 1. During the month of April our record at the orchard shows that the temperature reached freezing or below eighteen times.

To attempt to save all the varieties in the orchard would not warrant all the expense in labor and oil, so the orchard heating was not begun until the last week of April at a time when the largest number of varieties was in full bloom. The nights of April 6 and 7 were very cold, being 15° and 16°F. At this temperature numerous varieties of apples, both in the orchard and throughout the town, were frozen, even when the flower was closely covered with the green calyx. By smudging on April 30 from 1 to 6:30 a. m., on May 1 from 1:45 to 6:15, May 2 from 2 to 6:15, on May 3 from 2:30 to 5:30, May 11 from 4:30 to 5:30, we were able to save the crop on many of the trees.

Even if frost conditions had been at their minimum, like last spring, the apple crop this year would have been light, as the tendency was last year to overbear, and many varieties of apples are triennial bearers, *i. e.*, regardless of frost they would bear good crops only every other year.

We strongly urge the securing of a suitable site for a Station orchard that may be planted on a commercial basis with varieties suitable to the climate and until such time to postpone the frost-fighting investigations. There are no orchards, including the Station orchard, in which frost fighting could be carried on whereby the results could be interpreted as of commercial value to the prospective fruit-grower in northern Nevada.

At the suggestion of the Cederborg Engineering Company of Denver, Colo., we devised a system of colored electric lights connected with thermometers in the orchard whereby we could determine the temperature at various parts of the orchard while busy with the smudge pots. The thermometer acted in a similar manner to a switch, turning on or off the light at different temperatures. We will have a small crop of apples this year, but the individual specimens should be superb, as the trees have fewer to bring to maturity. A large number of varieties are represented.

Plant Diseases

A fungous disease on the Carolina poplar has been given some attention by Professor Frandsen, of the Department of Biology, and myself. Diseased material sent to the Pathological Division of the Forestry Department at Washington, D. C., was diagnosed as belonging to the genus *Cytospora*. They informed us that it has been heretofore only known to attack dead tissue, but were convinced from our report that it must attack living tissue in the West. We have taken photographs of the appearance of the diseased trees and of the fungus as well as studied the mycelium and spores. We propose to publish a bulletin on this subject.

Vegetable Growing

We have begun a series of tests to determine the best varieties of vegetables for general culture in this region. Many kinds of vegetables offered for sale in other markets are not to be found in Reno. An attempt will be made to introduce some of these. On account of the large amount of labor entailed in work of this character, we are confining our experiments to a single experiment each year. This year we have

planted eleven of the leading commercial varieties of onions on one acre, on what may be termed the average soil of the valley. Extensive cultivation of onions is confined largely to the alluvial soils along the Truckee River. Our experiment will determine whether onion culture could not be extended profitably to other lands in the valley. Next year we will test a large number of varieties of garden peas. We should like to see an additional greenhouse placed on the Campus for experimentation with winter vegetables such as tomatoes and cucumbers. These command a high price in Reno during the winter.

Native Vegetation as Soil Indicators

We have for a number of years noticed the close association between the character of the soil and the character of the native plants found growing upon it. It is well known that where the big black sagebrush (*Artemisia tridentata*) grows luxuriantly the soil is excellent for agricultural purposes. This information could be added to by determining the character of the lands upon which other native species equally abundant are found. This work should be carried on in cooperation with the Department of Soils.

The Flora of the State

This work has been continued as time permits. We now have about 14,000 sheets of plants in the herbarium, duly mounted and classified. These investigations have been largely carried on by Dr. A. A. Heller.

Clover Investigations

The investigations of clovers as a project under the Adams Fund have made considerable headway during the last year. We have published some preliminary papers and completed the section of Rabbit's-foot clovers. Numerous drawings of species in the other sections have been made. The completion of this work depends upon the amount of time that can be spared from teaching work under the Hatch Fund in horticulture and general routine work of direct interest to the State.

Forestry Investigations

Dr. A. A. Heller has devoted most of his time to the teaching of Forestry in the Agricultural College, and to the investigations of the poplars and coniferous trees of the State.

Drug Plants

At the suggestion of Dr. Rodney H. True, of the Division of Drugs and Poisonous Plant Investigations of the United States Department of Agriculture, we have this year begun an experiment with two plants which in certain parts of the United States have brought large sums of money per acre. These are wormwood and Indian hemp. Both are making excellent growth at the present time and give promise of success.

Weeds

For many years it was looked upon as somewhat of a joke to investigate weeds in the State of Nevada. Now, however, a number of weeds, like mustard, dandelion, and the wild morning-glory, have seriously interfered with the grain crops. At the present time it is difficult to find a grain field that is not yellow with mustard. The love vine, or dodder, is now widespread in the alfalfa. The wild morning-glory spreads in a few years from a patch a yard square to many rods in extent. We have attempted to eradicate it by applying different strength solutions of iron

sulphate, but to no purpose. The tops are killed, but the plants came up from the underground stems as thickly as ever. Deep plowing was also attempted, but this also fails. We were in hopes of discovering an easy method of eradication, but it is doubtful if there is any. This year we are hoeing off the tops as soon as they appear, with the theory that if the stems underground are not fed with the necessary starch-forming material from the air they must die. This failing, the last resort must be to actually dig out and rake together the roots and stems and burn them—a very costly procedure.

In regard to the mustard, we strongly recommend the purchase of a spraying outfit to demonstrate to the farmers that the mustard can be killed and yet leave the wheat crop unharmed. This has been tried in a number of States with success.

Twenty-four samples of seed, principally alfalfa, have been examined by the department for impurities.

State Experiment Farm

The writer has continued to act as Chairman of the State Experiment Farm at Logan, Clark County, Nevada. The direction of the experiments, the care of the finances, and the writing of the report entail a considerable amount of work in addition to the regular investigations of the department. It is valuable to the department, however, in that it gives it a very broad view of the needs of the State along agricultural and horticultural lines.

Extension Work

The writer joined the Utah demonstration train through the southern part of Nevada and spoke on horticultural topics. In Reno two lectures have been given on the flora of Nevada.

REPORT OF THE DEPARTMENT OF CHEMISTRY

C. A. JACOBSON

In my absence, Professor M. Adams, in charge of the collegiate chemistry in this University, wrote last year's departmental report and including a résumé of the investigations I carried out abroad. Having returned to resume the work in the Station, it would seem advisable to give a more detailed account of the results.

In this department two projects have been chosen for investigation under the Adams Fund. One of these is an investigation of the poisonous principles in some of the local poisonous plants that are doing most of the damage to stock. Work has been started on *cicuta vagans*, popularly called water hemlock or poison parsnip, and was continued for six weeks in Professor A. Pictet's laboratory at Geneva, Switzerland. Since returning to Reno that work is being continued here with the hope that it will be completed and published this fall. The other investigation, which thus far has received the major attention, is one whose aim is to better understand the mechanism of the fixation of atmospheric nitrogen by leguminous plants. If this question were thoroughly understood, it would doubtless be possible to so modify the conditions of the process as to obtain a larger yield of the fixed nitrogen.

Only the first steps of this work have been taken, in that a few of the organic constitutents of the alfalfa plant have been isolated and determined. When the essential constituents have been characterized, it is planned to determine what relation these compounds sustain to the nitrogen content and nitrogen-fixing power.

At first two ketones were isolated from the stem and leaves of the alfalfa plant. One of these, myristone, is a compound with twenty-seven carbon atoms, fifty-four hydrogen atoms and one oxygen atom in the molecule. The other, which the writer gives the name alfalfone, is also a ketone of similar properties, but of a little smaller molecular weight. A full chemical discussion will be found of myristone in vol. 33, page 2048, of the Journal of the American Chemical Society, and of alfalfone in vol. 34, page 300, of the same publication. The latter compound is entirely new. Heretofore the former has only been produced synthetically. This is the first time it has been obtained from a natural product.

Several other products had then been prepared in an impure state from alfalfa, but before working these up it was decided that a knowledge of the chlorophyll present would throw more light upon the problem. The chemistry of chlorophyll is a very difficult subject, and only two chemists have done very extensive work in this field. Furthermore, the apparatus necessary for such work is quite expensive and beyond our present means to secure.

The same conditions obtained for other phases of the alfalfa investigation as well, and it was decided to carry out certain parts of the work in foreign laboratories.

In the fall of 1911 I began the work on chlorophyll in Professor L. Marchlewski's laboratory at Cracow, Austria. Finding that no reliable method existed for determining the amounts of the two green components of chlorophyll in the presence of one another, we first set about to

develop such a method. In the meantime we concluded that it would be advisable to try to clear up the mooted question if the two components are always present in the same ratio or perhaps in equal proportion in all plants. After examining some twelve varieties of leaves we settled this question in the negative. The paper was published with seven tables and twelve spectrographs in the January (1912) number of the bulletin of the Cracow Academy of Science, and later in the American Chemical Journal, vol. 47, page 221.

As to the first question it should be said that two methods were worked out for determining neo and allochlorophyll in the presence of one another. One of these, the spectrographic, is very delicate and satisfactory. It is based upon the principle that the two chlorophyll components produce different absorption spectra in the ultra violet. By comparing the spectrograph of the solution to be determined with a series of spectrographs representing the two components mixed in different, but known, proportions, the concentrations being kept the same, one can read off its composition directly to within 1 or 2 per cent. The yellow coloring matters and other impurities do not interfere with the accuracy of the determination.

The presence of impurities in the solution renders the other method inaccurate and therefore of less value for general use. One of the components of chlorophyll, namely the neochlorophyll, was, for the first time, prepared in pure condition and its absorption spectrum photographed. This work was published in the February (1912) number of the bulletin of the Cracow Academy of Science and also in the American Chemical Journal, vol. 48, page 111.

Having produced a satisfactory method for analyzing chlorophyll, it remained to apply this to the chlorophyll products from alfalfa. This was done with the result that alfalfa contains 0.68 per cent chlorophyll in the air-dried leaves and 0.28 per cent yellow coloring matters. The particular lot of chlorophyll with which I was working contained 66 per cent neo and 34 per cent allochlorophyll, but this may vary in different lots and also in successive crops of alfalfa.

A full discussion of the above will be found in the Journal of the American Chemistry Society, vol. 34, page 1263.

Before leaving the chlorophyll work at Cracow, a plan suggested itself to us by which a method might be worked out for determining minute quantities of chlorophyll; for example, to determine the character and quantity of the chlorophyll in one small leaf. The method was successfully worked out, and is based on the principle of comparison of the intensity of the absorption bands in the ultraviolet spectrum of the chlorophyll solution whose concentration is sought, with the intensities of the corresponding bands produced by solutions of known concentration.

By this method it is possible to determine the quantity and character of the chlorophyll in a green leaf whose weight is only 0.2 gram. The method is described in the Journal of the American Chemical Society, vol. 34, page 1266.

From Cracow I went to Geneva, Switzerland, and began work on the cicuta or poison parsnip, with the results already noted. From there I went to Upsala, Sweden, where, in cooperation with Professor S. G. Hedin, an investigation was undertaken to determine the character of the enzymes present in alfalfa seeds. The work was of paramount importance to my larger alfalfa problem.

The results from this work show that alfalfa seeds contain an enzyme that hydrolyzes starch like amylase; one that hydrolyzes amygdaline like emulsin; one that coagulates milk like rennin; one that precipitates gallin purpuro from a pyrogallol solution with hydrogen peroxide like a peroxidase; and one that digests casein and Witte peptone as well as autolyzes the seed protein like a protease. The last-mentioned enzyme was characterized as a vegetable erepsin for the reason that it will not begin the digestion of a true protein like egg albumen, serum, legumin, or conglutin. Its casein digestion is inhibited by the presence of a small quantity of albumin or serum.

A full discussion of this work will be found in the Journal of the American Chemical Society, vol. 34, page 1730.

In addition to the above work a substance obtained from the alfalfa extractions, and labeled as Precipitate C, was characterized as a saponine. It gives all the important reactions of this class of substances. Its empirical formula and chemical transformations have not yet been worked out.

The chemistry of the proteins in the seeds and plant is another very important phase of the alfalfa investigation, which could better be carried out abroad than in our laboratory at home. This work was undertaken in Professor E. Abderhalden's laboratory in Halle, Germany. At first an attempt was made to isolate the principal proteins found in alfalfa seeds, but, meeting with serious difficulties along this line, we decided to investigate the influence of sprouting on the character of the combined proteins in the seeds. To do this we made quantitative determinations of the amino acid constituents obtained by hydrolyzing equal weights of seeds before and after sprouting. The hydrolyses were made and eight or ten amino acids of the one were isolated and determined. A similar analysis of the products of the other hydrolysis could have been finished in about three weeks' time, but unfortunately my health failed and I was obliged to give it up. Professor Abderhalden promised to complete the work and have it published. A résumé of this work will therefore be left for next year's report.

The total expense in connection with my foreign work, outside of salary, amounted to only $206.58.

This department has received no supplies in the form of chemicals or apparatus, nor have any improvements been made to the laboratory during the years 1911 to 1913.

My assistant, Mr. Fred. C. Henriques, was employed by the Pure Food and Drug Department of this Station during my absence and up to March of this year, when he accepted a position in similar work at Buenos Ayres, Argentine Republic, South America.

The present needs of the department are: additional laboratory space, where important instruments may be mounted and operated, an assistant chemist having had some research training, a laboratory helper to do the routine work, chemicals and laboratory supplies amounting to $450, scientific apparatus amounting to $735, and laboratory furniture amounting to $226, besides the ordinary running expenses. These are urgent needs, and the department cannot carry on its work efficiently without them.

Professor M. Adams submits the following report upon work done on wood distillation, carried out under the Adams Fund:

Samples of four different kinds of wood have been distilled and the products

examined. From a sample of "fat" yellow pine a clear water-white sample of light oil, boiling at between 158 and 178 degrees, and possessing many of the properties of the spirits of turpentine, has been obtained. This oil is now being examined to determine its chemical identity. Calculated from the results so far obtained, one cord of "fat" yellow pine should yield 26 gallons of this turpentine-like oil. Besides this light oil, there have been obtained from the same wood, acetic acid, methyl alcohol, creosote, wood tar, and charcoal of commercial value.

A sample of green yellow pine was also distilled and a sample of the above-mentioned light oil was obtained, but the yield was small, amounting to only about five gallons per cord.

Samples of sagebrush and pinus monophylla have also been distilled, but the assay of the distillate has not yet been completed.

Following is an itemized report of the water and soil analyses carried out by Messrs. S. C. Dinsmore and Miles B. Kennedy during the past year:

Soils (complete analysis)	12
Soils (alkali)	30
Sugar beets	1
Water (complete mineral)	15
Water (sanitary)	72
Mineral (complete analysis)	4
Mineral (partial)	19
Miscellaneous	12

DEPARTMENT OF ENTOMOLOGY

S. B. Doten

The Department of Entomology continued the same lines of work which were followed during the previous year. Among the insects under observation in the insectary was an alfalfa-plant louse, as yet unidentified, regarding which a paper is to be presented later by Mr. Cecil W. Creel. But little progress was made in the studies of certain cutworms injurious to alfalfa, since no reports came to the Station of such injuries, and none occurring in the immediate vicinity of the University.

Some scouting was done for the alfalfa weevil, whose introduction into Nevada may be expected at any time; but there is apparently no good reason at present for thinking that it has become established.

The experiments with the European elm scale were continued. A very careful test was made with methods and apparatus for washing a large number of elms of different species by means of a strong stream of water from a garden hose, and the usefulness of the method was more clearly demonstrated. It was shown also that some skill is required for successful washing by this method, and that the results depend primarily on the thoroughness of the work.

Under the Adams fund, studies of certain hymenopterous parasites attacking the codling moth were continued, and it became more apparent that the value of this project will lie largely in the light that the studies will throw on certain biological factors connected with reproduction and with the competition existing among several primary parasites and a number of secondary and tertiary parasites. Studies of the importance of food on the mature parasites were completed and will be published later.

The desire of the Entomologist to illustrate his forthcoming publications with photographs of living insects led him to make an exhaustive study of methods of illuminating such insect subjects. These studies bore fruit in a finished flash-light apparatus, electrically controlled, permitting exposures as brief as $\frac{1}{250}$ second. The examination of this apparatus by prominent entomologists led them to express so much approval that the writer is encouraged in the belief that this apparatus may prove of some use in other experiment stations. It will be necessary, however, to construct this apparatus under factory conditions, so that for its fullest usefulness it will be essential to interest a manufacturer of laboratory supplies and materials in the device.

While the department was greatly hampered by lack of means with which to hire labor and to purchase facilities, still the fact that the work was restricted closely to the purpose of the funds from which the Entomologist was paid made it possible to make some degree of progress.

DEPARTMENT OF METEOROLOGY AND CLIMATOLOGY

J. E. Church, Jr.
S. P. Ferguson

So far as funds have been available, the active prosecutions of the problems under investigation by this department have been continued.

Projects

These problems are:

(1) The Forecasting of Frost from Mountain Tops.

(2) The Relation of Mountains and Forests to the Conservation of Snow.

(3) The Temperature Survey of the Agricultural Lands of the State.

The solution of the first problem necessarily requires great perseverance. The mechanical equipment on Mount Rose is still causing some trouble, and some radical readjustment of the cylinders of the meteorograph may have to be made to assure uniform movement of the record sheet. Most other features of the equipment are now running normally. With one rewinding every five or six weeks, the standard pendulum clock in the observatory has run continuously since January under all conditions of storm and wind by which the tiny building is beset. The original price of the clock was only $12, yet during this period the clock has lost on an average only two minutes a month, which, under the circumstances is a very excellent performance. An anemometer has been made with the supporting arms passing around the back instead of through the cups, with the result that slugs of ice can no longer form within the cups and wreck them. The battery system is still a problem, and mechanical registration of sunshine may yet be necessary. Kite flights have been inaugurated to determine the meteorological error of Mount Rose. Heretofore the ruling of the continuous meteorograph sheets has been a serious problem. However, a ruling machine has been devised by which ruling may be easily and speedily done. An analysis of the data has been begun and will now be carried forward continuously to a conclusion.

Owing to uncertainty regarding the future of the snow studies, no attempt was made to employ an observer at Lake Tahoe until after the Legislature met, and then the regular observer could not be obtained. However, snow measurements on Mount Rose have been conducted each month throughout the winter, and interesting evidence has been gathered on the movement of snow fields under the impulse of the wind. Considerable progress has been made in the preparation of a preliminary bulletin on "The Conservation of Snow: Its Dependence on Mountains and Forests," and several short bulletins in the form of magazine articles have been published.

The snow sampler has been still further improved by using lighter material and employing shellac exclusively in place of oil to prevent rusting and the adherence of snow. By this means the adherence of snow has been almost entirely eliminated and with the result that one

man unaided is now able to drive the sampler to depths exceeding twelve feet.

Because of uncertainty regarding the amount of snow in the Tahoe Basin available for irrigation and power this season, the Truckee River General Electric Company and the Reclamation Service cooperated with the department in making a snow survey. Seventeen days were consumed in the work. Former courses were carefully followed and compared. According to data obtained there was from 25 to 30 per cent more snow in the basin this year than last, or 72.9 per cent of normal. From the data obtained last year in the course of the regular snow studies, Mr. L. O. Murphy, Hydrographer of the Truckee River General Electric Company, forecasted the summer level of the lake within one-tenth of one foot of the level actually attained.

Since this basin is large, the method of surveying by typical slopes has been devised, a sufficient number of typical slopes being chosen throughout the basin. New courses were added to the old, particularly along the main crest of the Sierra Nevada. Courses on Mount Freel in the Carson Range should also be added to increase the total measurements in the eastern half of the basin.

Publications

Several magazine articles and news bulletins have been prepared during the year. The former were considered necessary in order to protect data that had been gathered as early as 1909–10, but had not been published, partly because the results were radical and verification was desired, and partly because my time and strength were being fully absorbed in teaching at that time. The latter were reports of snow surveys on Mount Rose and in the Tahoe Basin. The magazine articles appear in the following list:

GENERAL

The Progress of Mount Rose Observatory, 1906-1912. Science, N.S., Vol. XXXVI, No. 396, pp. 796-800, December 6, 1912.

SNOW STUDIES

The Conservation of Snow: Its Dependence on Forests and Mountains. Scientific American Supplement, Vol. LXXIV, No. 1914, pp. 145, 152-155, September 7, 1912.

The Conservation of Snow: Its Dependence on Mountains and Forests. Official Bulletin of the International Irrigation Congress, Vol. I, No. 6, December, 1912; reprinted in Engineering and Contracting, Vol. XXXIX, No. 6, pp. 155-157, February 5, 1913.

Das Verhaltniss des Waldes und des Gebirges zur Erhaltung des Schnees. Die Meteorologische Zietschrift, Vol. XXX, No. 1, pp. 1-10, January, 1913.

TEMPERATURE SURVEY

Trailing the Frost Belt in Nevada Snows. (Title not our own.) Popular Mechanics, February, 1913, pp. 256-258.

Articles have been requested for publication by the Techno-Photographisches Archiv, Berlin, Germany, in Science Conspectus at the Massachusetts Institute of Technology, and in the transactions of the International Congress. These articles either await publication or are being prepared.

Cooperation

Like other departments, this department has sought to cooperate both within and without the University. Except for restrictions due to fiscal regulations, the U. S. Weather Bureau, through Professor A. J. Henry,

in charge of Rivers and Floods, and Mr. H. S. Cole, Section Director for Nevada, would have entered into occasional cooperative snow measurements. However, voluntary assistance has been rendered by both the Bureau and the Department. To aid the Weather Bureau in inaugurating snow surveys in the Carson and Walker River Basins, the sampler was loaned to Mr. Cole, with the result that two samplers were ordered for trial with a view of placing the sampler regularly in the service. Data from the temperature survey have also been loaned to the local office in order that a news bulletin could be prepared, directing the ranchers how to interpret the daily temperature reports. Among other activities, the Weather Bureau has assumed the task of issuing local and individual forecasts of frosts.

The temperature survey will be continued in the Truckee Meadows and at Fernley another season before any stations are removed to new locations. Although the data have not yet been fully analyzed, it is plainly evident that the higher slopes are, in general, more free from frosts than the lower. This difference also appears during the prevalence of "cold waves" in winter. When the air has been thoroughly mixed by high winds, the difference in temperature on the various slopes is practically indistinguishable.

By the aid of thermometers and observation of clouds and wind, considerable accuracy was attained last season in forecasting the degree of temperature to be expected on the following morning. To increase the accuracy of such forecasts, Professor Fergusson is installing a meteorological laboratory at the University largely at his own expense, where, by means of instruments of precision, the relation of cloudiness and humidity to the retardation of falling temperatures can be determined.

Except for a series of early frosts, the present season resembled last, when fruits of all kinds escaped serious injury. Even as it was, most of the apple blossoms would have escaped injury this season except for a single frost of 22.8°F., which destroyed buds as well as blossoms. Several orchardists who were planning to heat their orchards considered them safe because the buds were small, and so were not prepared for the abnormally low temperature that occurred.

Agricultural Meteorology

The activities referred to above are only a portion of those under way or planned, and represent pioneer work in agricultural meteorology, in which the underlying principles of climate in its relation to crops and fruits will be determined locally and applied to the welfare of the State.

This work does not duplicate that of the Weather Bureau, but rather precedes and supplements it. For this reason the study of meteorology in the Experiment Stations is now being welcomed and heartily supported by the Office of Experiment Stations.

Plans

The problem of forecasting frost from mountain tops is just emerging from the mechanical stage into that of analysis and discussion.

Among other projects awaiting opportunity is the forecasting of frost locally and the study of the relation of cloudiness and humidity to the retardation of radiation, to the end that greater accuracy can be obtained.

The causes of frosts and thermal belts have often been discussed, but no final word on this question has yet been spoken. The Truckee Meadows

offer ideal conditions for investigating this problem, and apparatus has already been accumulated toward beginning this work actively when other problems permit.

In December, Professor Fergusson was called to Dayton, Ohio, to testify in a patent case defended by the Wrights, and he used the opportunity afforded to spend a brief time at Blue Hill Observatory to prepare further equipment for the work and to consult with Director A. C. True and other officials of the Office of Experiment Stations and of the Weather Bureau at Washington regarding the future of the department. At Pittsburg Professor Fergusson was one of the speakers at a series of meetings called by prominent men to advance the interests of world meteorology, and at Boston was invited to address the Boston Scientific Society on the relation of snowfall to irrigation, and the meteorological work being conducted at Mount Rose observatory. Particular interest was shown in the long-time records of weather being obtained. He was also invited to build two large cellular kites to be used in procuring photographs of the volcano of Kilauea in the Hawaiian Islands. These photographs are to be used in preparing a model of this volcano for Harvard University.

DEPARTMENT OF VETERINARY SCIENCE AND BACTERIOLOGY

W. B. MACK

EQUINE ANEMIA

Equine anemia has continued the chief problem of this department during the year. There have been several cases in the same locality where the disease was first noted, but no extensive outbreak like those which occurred there during 1906 and 1907. In September we visited an outbreak in the extreme northern portion of Elko County, about 110 miles from the other locality. We saw there three or four cases of the disease. Horses on three or four ranches were affected, and several had recently died there from what the owners believed to be the same disease. There has been some loss upon these ranches during several years. The descriptions of the symptoms of those animals given by the ranchers appear to indicate that the trouble was due to the disease which we have under observation. There is no traffic between the two localities and no evidence that the disease has been carried from one locality to the other.

There is little progress to record for the year's work. Additional attempts to transmit the disease by inoculation and feeding virus have been made, using for that purpose blood, tissues, and body fluids taken from patients and obtained upon autopsy. Blood was taken from two patients in the northern locality, carried to the ranch where our experiments are being conducted and injected into two horses there. The result of all these experiments has so far been negative.

Clinical and pathological studies of this disease lead to the belief that it is infectious. Our early experiments appeared to confirm that theory, but later ones have had apparently negative results. This negative evidence is not, however, conclusive, and inoculation experiments will be continued as material is available until that point is determined.

Therapeutic experiments have been continued, but no successful treatment has been found.

HOG CHOLERA

No cases of hog cholera came to our attention during 1912. It reappeared this spring in the localities which were affected in 1911. It has not at this writing reached serious proportions, but it may do so as the season advances. This has given another opportunity to use the Dorset-Niles serum in several herds, and the results have been all that we could hope for. Our experience with the use of this serum in the control of hog cholera is limited, but that experience leads to the belief that where serum is properly prepared, tested and standardized, and then skilfully used, the result will not be disappointing. Thus far it has not failed in our hands with one or two exceptions, and the loss in those instances should have been avoided. In one instance several pure-bred pigs died during the simultaneous treatment. We failed to recognize that the resistance of pure-bred animals is less than that of scrubs, and that accordingly the dosage should have been increased. In another instance a lot of serum purchased from another laboratory was heavily contami-

nated. It put an end to cholera in the herd, but the contaminating organisms killed a lot of pigs. This was the fault of those who prepared the serum and is no reason for condemning the use of serum properly prepared. We refuse to send out serum to be used by farmers, but insist upon either using it ourselves or having it administered by qualified veterinarians.

It was our intention to publish early this year a popular paper upon the control of hog cholera by the use of this serum. Publication was delayed by the controversy which has arisen in some localities over the merits of the serum. We have come to the conclusion that it will control the disease if in competent hands and shall continue to advise its use where the circumstances appear to warrant it.

"SWELLED HEAD" IN SHEEP

In March it was our privilege to see an outbreak of "swelled head" in sheep. This trouble is occasionally reported among Nevada sheep, but this was our first opportunity to see cases of it. The condition as we saw it is an acute edema of the facial, maxillary and submaxillary regions. It appears suddenly and usually affects a considerable portion of the band. The mortality is reported by the sheep owners as usually high. The cause is unknown.

In this instance between 300 and 400 animals were affected out of a band of 1,600 yearling ewes. The cases all developed during twenty-four hours. We saw them at the height of the trouble and they presented a sorry spectacle. However, contrary to the usual course of the trouble, all but nine of them recovered.

One sheep was killed for autopsy. The viscera and all portions of the body except the subcutaneous tissues about the head appeared normal. There was an extensive edema of the subcutaneous tissues in the facial, maxillary and submaxillary regions. Those tissues were infiltrated and swollen to a thickness of from one to three centimeters. When incised a clear amber fluid appeared. From this fluid pure cultures of streptococci were obtained. With these cultures two Guinea pigs, two rabbits and two sheep were inoculated subcutaneously. Both Guinea pigs and one rabbit appeared to be unaffected. The other rabbit developed paralysis of the posterior legs in about three weeks after inoculation. The paralysis gradually ascended until the anterior legs and the entire body were paralyzed. Control of the head and neck only remained. The rabbit died on the thirty-second day. No lesions were demonstrable upon autopsy except that in sections of the spinal cord the central canal appeared to be dilated. The streptococci were not recovered in cultures. One yearling sheep was inoculated in the submaxillary region, but no effects were noted from the inoculation. The other sheep was inoculated in the superior maxillary region after bruising the skin and underlying tissues. This animal developed a swelling about the size of a large English walnut. At first it was firm and hard, but later it became somewhat "doughy." After a few days it disappeared. We have had no other opportunity to study this disease.

Whether the organism found in the edematous tissues bears any etiological relation to the disease was not demonstrated by these few experiments. If opportunity for further study of this disease presents, we shall undertake it.

MENINGITIS IN HORSES

During 1910 and 1911 a number of horses, burros, and mules died in Mason Valley from a disease which was never accurately diagnosed. One man lost eight horses in 1910; another lost between thirty and forty animals during the following winter; another lost two or three; another lost one; and there were a few other scattering cases in the valley. In January, February, and March, 1911, we saw a few cases. The symptoms resembled those related by various observers under the designations forage poisoning, epidemic cerebro-spinal meningitis, etc. Autopsies failed to reveal lesions of meningitis or in fact lesions of any particular significance. Treatment was attempted upon a few animals, but proved practically worthless, as most of those treated died. Two recovered, but it was probably in spite of the treatment rather than because of it. The mortality was very high; practically all of the affected animals died.

As stated above, no satisfactory diagnosis was ever made of those cases. To diagnose meningitis from symptoms alone when no lesions of meningitis were present was unwarranted. The forage consisted of clean alfalfa hay. There were no poisonous plants found in the hay. It was carefully examined, not only by the writer, but by a competent botanist, and there was no warrant for suspecting that it was the cause of the trouble.

During the last few weeks the disease has reappeared on the ranch where eight horses died in 1910 and taken five horses. We saw the last two during their illness and performed autopsies upon both. In the first there was a profuse amount of blood-stained cerebro-spinal fluid. Portions of this fluid were removed aseptically from the occipito-atloid region and from one of the lateral ventricles of the brain. Pure cultures of streptococci were obtained from it. Sections showed an extensive leptomeningitis. Cultures from the second case were negative. Sections from the brain and cord of this case have not yet been studied. Whether the streptococci isolated from one case might have been found in all—that is, whether all cases were caused by infection with this species of bacteria—or whether this was one of accidental infection of the central nervous system, is an unanswered question. Possibly the future will afford opportunity for further study. In that case every available animal will be thoroughly studied.

INFECTIOUS ABORTION IN CATTLE

In Carson Valley, one of the principal dairy districts of the State, infectious abortion is the cause of heavy losses. Cultures of what appears to be the abortion bacillus, described by Bang and others in Europe and by several investigators in the United States, have been isolated from an aborted fetus. It is our intention to undertake some field experiments to determine if we can produce immunity in virgin heifers and uninfected cows by the use of bacterins prepared from the abortion bacillus and to test these bacterins in the treatment of infected cows.

INFECTIOUS MASTITIS

Several cases of streptococcic mastitis in dairy cows have come to our attention recently. The usual treatment is not effective in many of these cases and the usual final result is the loss of the infected mammæ, so far as the production of milk is concerned. We have several of these cases

under treatment with autogenous vaccines. It is yet too early to determine whether they will yield to this treatment, but the indications are somewhat favorable.

INFECTIOUS ENTERO-HEPATITIS IN TURKEYS

One case of infectious entero-hepatitis in a turkey was brought to the laboratory recently for diagnosis, from the vicinity of Reno. A similar case was sent to us from Carson City in 1910.

TEACHING

During the second semester of the year five university hours of instruction was given to the senior and junior students in agriculture. During the Farmer's Short Course in February, lectures on bovine tuberculosis and hog cholera were delivered and the tuberculin test demonstrated, followed by autopsies upon the reacting cattle.

PUBLICATIONS

There were no publications from this department during the year.

DEPARTMENT OF LIBRARY

MRS. T. W. COWGILL

In the year ending June 30, 1913, but few books have been bought. Accessions from all sources amount to only seventy-four volumes.

The bulletins, periodicals, and pamphlets received have been filed for use or stored. It is expected that a large number of these will shortly be bound.

The suggestion is submitted that an appropriation for binding, available annually, would make it possible better to preserve such loose matter and at the same time keep it in more convenient form for reference.

The usual edition of bulletins has heretofore been 5,000 copies, of which the library has been expected to retain not less than 500 for use. The mailing list, state and general, has steadily increased and now includes about 5,800 names. It is obvious that the Station must cease to supply the whole demand, or that the edition must be increased. For the present an edition of 6,500 would be sufficient.

AVAILABLE BULLETINS OF THE
NEVADA AGRICULTURAL EXPERIMENT STATION

No.	Title
17.	The Woolly Aphis of the Apple.
23.	Sugar Beets.
28.	An Important Elm Insect.
29.	The San José Scale.
30.	Wheat-Cutting at Different Dates.
31.	Texas Cattle Fever.
32.	Sugar Beets.
33.	Field Notes on Some Nevada Grasses.
39.	Some Nevada Soils.
40.	Pig Feeding.
43.	Sugar Beets.
44.	Sugar Beets.
45.	Twigs of Common Trees and Shrubs.
47.	Clover Seeds and their Impurities.
49.	The Carpenter Worm.
50.	Sugar Beets.
51.	A Preliminary Report of the Summer Ranges of Western Nevada Sheep.
52.	Water Supply and Irrigation in Nevada.
53.	Burning Dead Animals.
56.	Crickets.
62.	Native Forage Plants and their Chemical Composition.
66.	Annual Report for 1908.
69.	Irrigation Laws and Litigation in Nevada.
70.	Food and Drug Inspection.
71.	Digestion Experiments on the Range.
73.	A Neglected Field in Photo-micrography.
73½.	Annual Report for 1910.
74.	Report of Department of Food and Drug Inspection, 1910.
75.	The Sugar-Beet Industry in Nevada.
76.	The Potato Eelworm.
77.	Fixing Standard Weights and Measures.
78.	Hymenopterous Parasites (Technical, Entomology).
79.	Avoidance and Prevention of Frost in the Fruit Belts of Nevada.
	Annual Report for 1911.
	Annual Report for 1912.
	Report of Food and Drug Inspection, 1912.
	Report of Weights and Measures Department, 1912.

Copies of the above may be had by applying to

DIRECTOR, NEVADA AGRICULTURAL EXPERIMENT STATION,
RENO, NEVADA.

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AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Annual Report of the Board of Control for the Fiscal Year Ending June 30, 1914

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

CARSON CITY, NEVADA
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
1915
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THE NEVADA AGRICULTURAL EXPERIMENT STATION

THE BOARD OF CONTROL

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LETTER OF TRANSMITTAL

To the President and Board of Control, Nevada Agricultural Experiment Station, University of Nevada.

GENTLEMEN: I have the honor to transmit herewith the annual report of the Agricultural Experiment Station for the year ending June 30, 1914.

It is our plan to conform the work of the Station in each succeeding fiscal year more closely to the type of agriculture found in Nevada; in part through the development of a number of additional projects in the Department of Bacteriology and Veterinary Science. This will necessarily require reductions in allotments made to some of the other departments. However, while it is intended that the Station shall specialize in one or two lines closely allied to the great stock industry of the State, the change will be made gradually enough so that work upon existing projects in other departments will not be injured.

There is every opportunity, especially in the Department of Bacteriology and Veterinary Science, for experimental work and research work, which in the long run may prove serviceable to the whole livestock industry of western America.

Respectfully submitted,

S. B. DOTEN,
Director.

JOSEPH EDWARD STUBBS

1850-1914

Director Nevada Agricultural Experiment Station, 1894-1912

It was the privilege of the present Director to work and study in the Nevada Station during almost the whole period of Doctor Stubbs's directorship.

In Doctor Stubbs the members of the Staff found a leader and a true friend. As an administrator he had a rare gift for developing enthusiasm and ability in others, the gift of making a man feel the significance of his work. He found genuine delight in developing ability and character in younger men; for he was at heart an educator. He prized the initiative of his colleagues, and took personal pride in the work and the accomplishments of men whom he had developed.

Although himself not trained in the methods of scientific investigation, President Stubbs saw with insight and wide vision the vast and fundamental importance of research in the building of civilization. He saw that from pure science springs true knowledge of the nature of that great universe of which we are all a part. As an educator he realized that progress in control of the forces of nature must be based upon a developing knowledge of her fundamental laws.

S. B. DOTEN.

ADMINISTRATION

S. B. Doten

Following the resignation of Director Gordon H. True, the appointment of a new director of the Nevada Agricultural Experiment Station did not take place until after nearly a fourth of the fiscal year 1913–1914 had elapsed. It was necessary, therefore, for the new director to assume responsibility for the entire year. The withdrawal of members of the staff, with the consequent abandonment of projects, together with certain other conditions, made it essential that the entire organization should be recast and that a definite policy and plans for the future should be outlined.

A careful study of conditions in the University of Nevada, with an examination of methods in the University of California and a visit to the Department of Agriculture in Washington, D. C., indicated the conditions under which the Nevada Station could hope to succeed. In the first place it was apparent that the field of work must be narrowed; that all the work of the departments should be stated in project form; that funds should be allotted in advance and after most careful consideration for the work on the projects; that laboratories and offices should be so equipped as to give every opportunity for the making of elaborate notes of work in progress; that a method of handling the funds should be worked out, which would give the necessary elasticity to the work of the departments and which would at the same time permit of most careful supervision of the expenditures throughout the year.

In the course of the winter of 1913–14 all the work of the Nevada Experiment Station was restated in project form—that is, both the Hatch Fund and the Adams Fund were allotted only to the support of experimental work and researches, proceeding according to definite preconceived plans.

In the year 1913 Mr. L. T. Sharp, then in charge of the Department of Soils in the Station, outlined a well-planned project on the biological fixation of nitrogen. In the reorganization it seemed preferable to abandon this project before the work was really begun, just because of the greater relative importance of other lines of work. Since no man works well in research according to another man's plan, and since a project usually represents a special ability or special training on the part of the man who originates it, it seemed wiser, on the whole, not to carry forward the work in this field.

Another line of work was growing toward completion in the Department of Botany, Horticulture, and Forestry, under Doctor P. B. Kennedy. This was a study of the economic status of the genus *Trifolium*, and the systematic aspects of this group. It was to be issued as a monograph of the genus; and the project included the results of many experimental plantings of seeds never brought before under cultivation. So mature and important a project could not be abandoned without a great loss: in preceding years several thousands of dollars had been expended upon it from the Adams Fund. To find a man capable of taking up this work where Doctor Kennedy left it would

be almost impossible, and to train a man for just this special field of work would require several years. Under all the conditions it seemed best to propose that this project be transferred bodily to the University of California, where Doctor Kennedy was about to enter upon a new field of work. Through a fortunate arrangement with Dean Thomas Forsythe Hunt of that institution, the transfer was made, with the understanding that when the results are published, all due credit will be given to the Adams Fund and to the University of Nevada.

The work of the Department of Animal Husbandry in Nevada was organized almost from the beginning more for extension and demonstration than for experimental work and investigation; although promising experimental work in that field had been attempted. Upon the resignation of the head of that department, Gordon H. True, to take an advanced position with the University of California, responsibility for the department was assumed wholly by the divisions of teaching and extension; and plans were made to reorganize on a basis of teaching, demonstration, and public service rather than on a basis of experimental work and research. To the writer's mind this was the wisest course, since the department had demonstrated clearly the lines of work in which it could be most helpful; and had indicated how great is its possibility of development under favoring and unrestricted conditions. Moreover, certain leading cattlemen of Nevada have expressed the opinion that it is not so much in the simpler problems of breeding and feeding that they look to the Experiment Station for assistance as in the more difficult field of animal diseases, where experimental work and research of a high order are demanded.

There are opportunities for tests in cattle feeding; but on the whole these simpler tests are mainly of local interest, and often of variable and temporary significance owing to changes in prices of cattle and feeding-stuffs. It will be better, therefore, to finance such tests, not from federal funds, but from the funds of counties or of the State in cooperation with cattlemen and livestock associations.

In the winter of 1913–14 cooperative feeding tests, well planned and under expert supervision, were carried on by the University of California in cooperation with the Western Meat Company in the vicinity of Lovelock, Nevada. It is needless to say that these tests were welcomed by the University of Nevada; for, when the results are published by the University of California, they will readily be made accessible to the cattlemen and farmers in Nevada.

It will be seen that in the Nevada Station the resignation of many members of the staff just before a change in administration made some reshaping of the policy and the projects of the institution readily possible; while formerly it would have been difficult. In the reorganization, plans were made for work on projects in the following sciences: entomology, plant pathology, chemistry, meteorology, agronomy, and veterinary science and bacteriology. Even in these sciences, it was essential to limit the work to a few definite projects for whose study the type of agriculture found in Nevada offers special opportunity. Our projects as outlined fall into three groups: (1) Entomology and Plant Pathology, primarily the insect-pests and diseases of alfalfa and potatoes; (2) Chemistry, studies of the chemistry of alfalfa and of certain plants

poisonous to live stock, with studies of the valuable properties and possible uses of certain desert plants; (3) Agronomy-Meteorology, water studies, including the application of water to plants in the field, and studies of water for irrigation at its source in the melting snow of the mountains; (4) Bacteriology and Veterinary Science, studies of certain animal diseases.

No attempt is made to cover the whole field of agriculture at one time; simply because it is out of the question to do a high grade of experimental work under the two limited federal funds without severely restricting the number of projects and of fields of work.

If in Nevada other fields of experimental work shall assume greater importance as new problems arise with the development and specialization of agriculture, it will be essential for the State of Nevada to allot funds for the study of such problems in addition to those funds now appropriated by the federal government.

The use of the word "project" in connection with the scientific work of the Experiment Station deserves explanation. A project is first of all a plan. It is more than a statement of a field of work to be undertaken, or of a subject chosen from within that field: it is a definite, well-worked plan for the solution of a problem or for the exploration of an unknown region in agricultural science. Thus, the statement of a project involves an outline of the nature of work to be done and of the means and methods to be used in doing it. The assertion that the work of a station is not done according to project would seem to imply that it is not done according to plan, that to a degree its work is unspecialized, not methodical. If we say that the scientific work of any station is done by a project and budget system, the reader may well ask: "Why, how else could it be done? Does not the very word 'experiment' or the word 'research' imply an investigation planned in advance?"

The undertaking of a line of investigation in any field of applied science means the hiring of men, the equipment of a laboratory or the preparation of land, the purchase of expensive appliances and apparatus. It is not a thing to be undertaken lightly. Only the presence or the availability of a trained man of demonstrated fitness, the presence of ample material for the study of a problem of genuine significance, the presence of funds which can be allotted steadily year after year for the continuous study of the problem through many years—only so complete a set of favoring conditions will justify the station in undertaking work upon a new project. And, even at that, the one condition of primary importance is the availability of a man of demonstrated fitness for the peculiar field of work to be undertaken.

Finances of the Nevada Station.

With the exception of occasional small appropriations from state funds, the Nevada Agricultural Experiment Station has been supported from the beginning by two federal funds under supervision of the United States Department of Agriculture. These two federal funds established by the Hatch Act of 1887 and the Adams Act of 1906, amount to an annual total of thirty thousand dollars. This sum is spent yearly by the University of Nevada in its Experiment Station. Several times in the course of the year the Nevada Station reports to the Office of Experiment Stations at Washington, D. C.; then, at the

time of the annual inspection, it becomes necessary for the men of the Station to satisfy an inspector representing the Department of Agriculture that the work of the Station is of the type contemplated by the federal grants, and that the money granted has all of it been expended strictly in connection with this work.

Although the funds come from Washington, the subjects to be studied and investigated will be found within the State. Like almost every other State, Nevada offers opportunities for the study of certain special problems. It is expected that purely local tests and experiments will be paid for from state funds, while the federal funds will be spent, as they should be, for the scientific investigation of problems of larger importance and more general interest.

Nature of the Work To Be Done Under the Federal Funds—Need of State Funds for the Support of Certain Sides of the Work.

Very wisely, then, the Hatch Fund and the Adams Fund are restricted to scientific work done by the methods known as experimentation and research. Used in this connection, there is no sharp line between the two; except that research is taken to imply deeper, more thorough, and more fundamental investigation of a problem in some field of science allied to agriculture.

Still, even in this field of research and investigation, every experiment station needs funds from the State in order that its work may be flexible and efficient. For instance, if an outbreak of disease among sheep occurs in a remote portion of Nevada, it is hard to tell at the outset just what is the nature of the trouble. It is sometimes out of the question to determine in advance and without a careful study of conditions whether the disease will be a suitable subject for scientific investigation. It may be a thing well known, something which has been worked out most thoroughly in another State or in Europe. It may be something obscure, unusual, hard to diagnose, a disease of which the scientific world has little knowledge. If the disease is one well known, it is not a subject for scientific investigation under the federal funds; it is not a matter for the Experiment Station to study and investigate; it is a disorder to be treated promptly along well-established lines. Leadership in the matter of treatment, instruction in methods of cure and prevention then become the work of the men in extension and demonstration working under state funds or under the new federal Smith-Lever law.

It is evident that, while the Hatch and Adams Funds do provide means for the deep and thorough study of fundamental problems, the Experiment Station has need of other funds which may be used more freely for the preliminary investigation of troubles which appear, and for scouting trips throughout the State to study the conditions which exist.

Lines of Work Which Cannot Be Undertaken Under the Federal Funds.

Plainly, too, under the federal funds, limited, as they are, to a scientific study and investigation of new and difficult things, the Experiment Station does not undertake miscellaneous analyses of soils and waters, of the stomach contents of dead animals, or of any similar matters. Nor can the Station inspect nurseries or gardens, nor conduct quarantine work under these federal funds; nor can it conduct campaigns of extermination against insect pests or plant diseases; nor may it carry

on farm operations in various counties with a view of teaching the local farmers how to farm better. All such local matters have to be taken care of by other departments of the University or by the counties or the State.

In several of the States, various miscellaneous duties have been added to the experiment stations by State Legislatures; inspection and quarantine work, the operation of demonstration farms, so-called "experimental" farms and the like; but unless the State Legislature provides funds to pay in full for materials used, for the salaries of the men employed, for their traveling expenses, for the publication of their reports, then the state laws in question must remain inoperative. We cannot take men from duties for which they are paid from federal funds and send them out in the interest of the State to work in other and quite different lines without compensation. Some of the serious troubles, which have arisen over apparent misappropriations of federal funds, have arisen purely from misguided state laws, whose enforcement would bring the Station into conflict with the purpose of the federal government.

The Nature of the Research Work of the Station.

Under the Hatch and Adams Funds, then, the field of work of the Experiment Station is the scientific study and investigation of problems by highly trained men. If the problem is that of the true nature of an obscure horse disease, then its study will require an expert in bacteriology and veterinary science. An outbreak of a serious insect pest may require years of study of the insects involved; and such an investigation will tax the skill of a trained entomologist. The scientific study of stream flow and water conditions may involve the investigation of water at its source in the melting snow of the mountains. Such studies must continue for many years before the relation of forests and snow to the flow of water in the streams can possibly be worked out.

On the whole, the genuine contributions to knowledge made in any year by any single experiment station must be few in numbers and often relatively unimportant. Still, the annual contribution made by the whole great group of stations is increasingly large and important. It grows year by year as methods of study are perfected and as the need of deep and thorough investigation of fundamental problems makes itself always more keenly felt. It is eminently suitable that such work be done under funds provided by the general government, subject to the supervision of the United States Department of Agriculture.

Few men are in any true sense fitted for research and investigation. Much depends upon the training of the man; more upon his native ability, the natural gifts and endowments of his mind. It is easy enough to endow a college with money: it is hard to endow it with brains. Men of intelligence, men of rare natural gifts, may be attracted to an experiment station if conditions in the state university, to which it is attached, are favorable to a man's best development of his best self.

Conditions Favorable to Research.

And what, then, are the favoring conditions which make possible in a university a high type of research? A careful canvass of the faculty

of one of the larger and older institutions brought out the following opinions:

(1) Noninterference with the time, the plans, and the work of the research men: this is a negative condition; why should it be the condition thought of first of all? Perhaps because it is just the one condition hardest of all to obtain and to maintain in the American state university.

Changes in boards of control and in administrative heads, changes in buildings and equipment brought about by rapid and poorly coordinated growth, pressure by the people for immediate results from researches which can bear fruit only after prolonged development and in the course of time, a lack of popular appreciation of the outstanding value of laborious unselfish investigation, the itching for publicity which afflicts many estimable colleges, combinations of teaching or extension or other duties ill-mated with research, vexatious and disturbing financial systems—all these things and many others break into the time and the thought of men engaged on research problems, oftentimes to the ruin of well-planned work.

Under such conditions many a piece of research, well conceived and promising, has dwindled like a tree planted in a cellar, until it has died at last and borne no fruit.

Sometimes, too, the pressure for immediate results has led to a shallow popular work, or to a jumping at conclusions akin to quackery. Sometimes legislatures have been led to make great appropriations to such work, because of its popular and flashy character; and their money has been wasted. Even in hurried America, there is no way in which we can force the tree of knowledge to bear fruit.

(2) Another important set of conditions allied to the first is that supplied by the type of supervision and direction in vogue. In a research institution, the only form of administration or direction, which can be successful, is the type implied in the word *leadership* rather than direction. Above all other things, research, scientific investigation, is the product of the individual mind, or of a group of minds working on related aspects of the same problem. Research is original, original in means and method and in the end sought. If it is not original, then it is not research. No man can tell in advance what are to be his methods and what his results. If he can tell, then his work is not investigation at all, but demonstration; a retracing of the path found by other minds.

The whole trend of thought in college and station work in America indicates that the greatest responsibility of the administrative head, his duty and his pleasure, must be to attract and to hold strong independent minds free in thought and fearless in character: and then, subordinating the machinery of administration, to lead those minds into the best and highest and most original service to science of which they are capable.

The supervision exercised by the director, then, should be of the simplest type: it should consist most of all of leadership in the development of the finest and truest work of other minds; for it is true that good administration in research, like good literary style in writing, sinks itself and loses sight of itself in the things said and in the work and thought. The director shows his truest leadership in the interest and

enthusiasm which he feels for the planning of the work, and for its progress and success, in his loyalty to work well planned, in his sympathy and patience with its necessarily slow development.

In its relation to the whole university as a division or department of the larger whole, it becomes increasingly evident that genuine scientific investigation can be carried on, if at all, only where the atmosphere of the university is just, thoughtful, and conservative and in accord with the best traditions of university life and thought.

The Experiment Station as a Graduate School.

The one central aim of the experiment station is research. It works for progress in the sciences related to agriculture. It means progress in the study of plant diseases and insect pests, progress in the study of the inheritance of characters in plant and animal, progress in the study of water and soil and their problems. Its ultimate object is the advancement of knowledge and civilization.

Why may we not make of the experiment stations graduate schools? That is what they soon come to mean to the men who do research work in them under happy auspices. When the atmosphere of the university is favorable to research; when men are recognized and honored by their colleagues and by the governing board because of the high character of research papers which they have published, then the experiment station becomes a school, a higher university for the members of the staff. In many a university, the young man working for his doctor's degree in regular course is not enough alone: he is not forced to draw heavily enough upon his own resources. Only too often the man doing research work in a university, in preparation of his thesis for the doctorate, develops not so much his own ideas and lines of thought as those of the teacher whose mind overshadows him.

Nobody whoever taught plane geometry in all earnestness has failed to feel that the best examination in that subject is merely a set of original problems. It is in the solution of these original problems that the pupil shows, not what he has been taught, not what he has memorized, but his growing power to use what he knows in developing further mathematical knowledge.

In the same way, a research problem in an experiment station forms an excellent test of what the man really knows and can do toward the development of that new knowledge, which advances human progress.

Where conditions are right, in any experiment station large or small, the station might well come in time to be accredited as a post-graduate school to several of the larger universities; because of the stable conditions, the efficient administration, and the fine and wholesome traditions of the university of which the station is a part.

Thus the larger and older universities might well place students of exceptional maturity and promise in the experiment stations to work upon special problems. The station should furnish books, laboratory, equipment, money enough to enable the aspiring research student to live in relative comfort. But, above all, it should supply an atmosphere which would welcome and stimulate and encourage the keenest thought and the bravest effort. Upon the completion of the work to a definite stage, it should be published as the station's contribution to knowledge in that field and as the thesis of the aspirant for the doctor-

ate. The completion of successful work, giving evidence of genuine ability, would almost inevitably lead to the employment of the man in experiment station work. Thus the stations would enrich themselves by adding to their workers young men of demonstrated ability, of marked promise for the future, and of thorough preparation.

Yet another way in which colleges of high grade and established reputation may do much toward advancing the scientific character of the work done by the experiment stations is by conferring the doctor's degree on men now in station work, whose bulletins form a genuine contribution to knowledge.

The Relation of the Experiment Station to the State University.

The experiment station is a division of the college rather than an affiliated research institution. It is needless to call attention to the advantages of this relation. It is difficult to think of the station as a department, since it consists in itself of so many departments, or of men working in so many departments of the college. Thus, an experiment station may have a research worker in botany or in agronomy or in plant pathology, one in entomology, one in veterinary science, and so on throughout the whole list of the scientific specialties which are related to agriculture.

I am under obligation to a member of the Faculty of the University of California for the following diagrammatic account of what would seem to be an excellent form of departmental organization:

Teaching	Research	Public service	Extension
Professor	**John Doe**		
	Dr. Hermann Moe		
	J. S. Hoe		
	Professor	**Richard Roe**	
		James	**Coe**
			Henry Goe

In explanation of the plan, it is sufficient to say that, as drawn, Professor John Doe is at the head of the department, and that aside from exercising general supervision over the department, he is doing some teaching and is engaged upon certain research problems. Again, Professor Richard Roe is doing some public-service work, and is at the same time working upon a limited research problem in the laboratory. Doctor Hermann Moe, as will be seen, is engaged on nothing but research problems.

Now, out of all the men engaged in the work of the department in the above diagram, only one or two, the department head, let us say, and one other research worker, really belong to the experiment station.

There can be little question about the great value of a close connection between the station and the college. The research man is brought continually into contact with other points of view. If he discovers information of value, it is promptly embodied in the teaching courses covering that subject. If it has a direct practical application, as it may well have, then it will be taken up by the extension workers and taught by them to the people. If research gives facts capable of demonstration

in the field, then the facts may be demonstrated to the people under the Smith-Lever Fund for extension. The research man sees only a corner of his subject; the head of the department surveys the whole field. Thus, the department head is encouraged to be always on the alert for the fundamental problems of agriculture, always eager to be of assistance.

And, again, the fact that there is research work in progress in a department is a fact of primary importance to teaching, to extension, and to public service. All of them alike catch something of the spirit of investigation. Unconsciously all alike begin to demand that a man shall know why he does the thing, as well as what he is doing. The research spirit, originating among the men of the experiment station in a state university may well come to influence the thought and the life of the whole institution.

It is well for the scientific investigator to come into contact with men of the language group of the faculty, just in order that the scientist may realize the limitations of scientific method and of scientific thought and may come to know that beyond his own outlook there are fair horizons and undiscovered countries. And, again, on the other hand, it is well for the men who are primarily students of language and literature to realize the deep significance and the wonder of the material world of the men of science; for, without some knowledge of modern biological and physical science, no man is truly fitted, truly educated, for the mental and material environment of the present day.

Form of Organization.

(1) The experiment station consists primarily of a group of trained men working under the leadership of a director. Each within the field of his special training conducts investigations connected directly or indirectly with agriculture.

(2) These researches are stated in advance in the form of projects—that is, a careful statement is made of the subject, of the problem connected with that subject for which a solution is sought, and of the methods which will probably be used for its solution. The project is approved by the director, is submitted for advice or approval to the Office of Experiment Stations of the U. S. Department of Agriculture: upon approval it is submitted to the Board of Control of the Experiment Station.

Each project should stand the test of three questions (Dean Thomas Forsythe Hunt, the College of Agriculture, the University of California):

1. Is the subject which is to be studied worth while?
2. Are the proposed methods of work calculated to give the result sought?
3. Is the station in a position to finance the project as it should be financed in order to carry the work forward steadily to a successful conclusion?

(3) Prior to the beginning of the fiscal year, the two funds, Adams and Hatch, are allotted for the support of the projects which are to be maintained from those funds during the year. Suitable amounts are reserved for the cost of administration, for publications, for clerical assistance, for the library, for new projects arising from unforeseen conditions and the like. These allotments are purposely made some-

what indefinite and as flexible as possible in order that the work may not be hampered by a rigid, preconceived financial plan; for it would certainly be injudicious to attempt to plan a definite financial budget down to the last detail for work with living material in course of development; that is, for research work whose direction and ultimate outcome are never predetermined. Here the element of flexibility is essential.

(4) Expenditures are made by requisition. The requisition system should be as simple as possible; for an overelaborate system of requisition, and order, if conscientiously followed, is expensive, inefficient, and an obstacle to progress in research. Since no one can tell, or foretell, what will be the outcome of a piece of research or investigation, or what may be needed in detail for its successful prosecution, it will sometimes be necessary to make expenditures, even of considerable amounts, with the utmost promptness and under conditions where a delay of a few days could greatly injure the progress of months of effort.

(5) The members of the Board of Regents of the University are also the Board of Control of the Experiment Station. They meet with the Director occasionally as a Board of Control, and receive reports upon the condition and the progress of the Station and they discuss with the Director and the President of the University matters of policy, of method, and of plans.

(6) The Experiment Station is inspected annually by the Office of Experiment Stations of the U. S. Department of Agriculture. The representative usually spends three days in this inspection, taking up the finances of the Station with the University Comptroller, matters of policy with the Director and the President, and taking up the interests of the departments with each one in turn. The inspector then makes his report to Washington, and, upon favorable recommendation of the Office of Experiment Stations, the Secretary of Agriculture certifies to the Secretary of the Treasury that the Station is entitled to its share of the next annual appropriation. Upon an unfavorable report, however, the Secretary is authorized to withhold certification, thus suspending payment, and to report the matter to Congress.

(7) The very center of the work of the Station is in the notes of work and results on the various projects. Up to the time of publication the only evidence that work is really progressing is in the notes and records slowly accumulating. Thus, at any time, in the keeping of the departments, the Experiment Station has a quantity of information which it has cost many thousands of dollars to obtain. This information is all embodied in the written notes, photographs, and other records of all kinds which are the most vital property of the department. A fire could sweep away in an hour the accumulated notes of years. The deep significance of such records, the expenditures which they represent, the fact that they furnish the only possible evidence of the character of the work in progress, all go to show that as an ordinary and reasonable precaution they should be made and filed in duplicate. On the sudden death of an investigator, or upon his sudden call to a more remunerative position elsewhere, his notes should be so filed, indexed,

and arranged that every record will be intelligible to his successor without explanation. One set of departmental records should be kept constantly for reference in the department; another set should be kept in a fireproof document safe in the college building least exposed to destruction by fire. All such records, drawings, notes, and photographs should be regarded as the inviolable property of the Experiment Station; and any man who is called to an advanced position elsewhere should be released only on condition that his notes and records are so filed, indexed, and duplicated that they may be accessible and wholly intelligible to his successor. In fact, the university calling the man should first ascertain that he is leaving his notes and every form of record completely filed and indexed.

The Way in Which the University of Nevada Can Best Be of Service to Agriculture Under the Conditions Within This State.

On the whole, agriculture in Nevada is not far developed nor highly specialized. But just because of this possibility of development and specialization in agriculture, there is in Nevada perhaps not quite so much need of experimental work as there is of extension and demonstration. Nevertheless, under proper conditions for research, the Nevada Station should offer an unusual opportunity for the successful prosecution of work on projects through many years. With but few projects, and those well financed, it should be possible for the University of Nevada to do work in its Experiment Station of so high an order that it will be accepted everywhere.

Each year we should publish a few papers of high scientific character. Those few should be widely applicable and of definite connection with Nevada agriculture. Meanwhile, the agricultural interests of the State will be further served to good advantage along quite other lines. It seems at present rather more important to carry out to the farmers those well-known facts, which find application to our conditions, than it is to delve and investigate in the region of the unknown. It would seem, therefore, that the experimental work of the Station will need only a moderate appropriation from the State for general scouting and preliminary investigations of troubles to find out their true nature.

The one great fact which stands out in the whole agricultural situation here in Nevada more prominently than any other is the great primary need of extension and demonstration work—that is, of personal contact and teaching in the field. We need to teach many of the old well-known facts and many of those facts which are new, or which have originated in modern farm practice of the best type. This has been our great need for years.

It is only common fairness to our former Director, Gordon H. True, to say that he felt this need and tried to meet it. The influence of his discriminating judgment of blooded stock will long be felt in Nevada.

In serum work with animal diseases, in demonstrations of improved varieties of crops, in the breeding and the introduction of blooded cattle and horses and hogs and sheep and poultry, in demonstrations of the methods of fighting frost in orchards, in the introduction of improved methods of bee-keeping, and in the elimination of foul brood from the

hives, in the fight against anthrax and hog cholera and bovine tuberculosis, and in the improvement of homes and methods of farming on isolated ranches, there is every opportunity in the world for work that will count immediately and steadily for the betterment of conditions in the farming regions of Nevada.

Right now the men of the Experiment Station can only wish the extension workers God speed! In their work we see the fulfilment and fruition of our own. We can redouble our efforts for the highest grade of experimental work and research of which we are capable, realizing that, for every fact which we discover, new uses and new applications will be found here and everywhere.

DEPARTMENT OF VETERINARY SCIENCE AND BACTERIOLOGY

WINFRED B. MACK

Equine Anemia

Our study of equine anemia has constituted the major portion of the work of the department for several years. That work has been continued along the same lines as in former years, but has resulted in very little progress of late.

There were but a few cases of this disease during the year in the district where our observations are being conducted. Reports as yet unconfirmed indicate the occurrence of the malady in certain valleys to the eastward.

Two inoculated horses died during the year. The first to die was under experiment for nearly five years. She received her first inoculation September 2, 1908; was reinoculated October 19, 1908, February 8, 1909, and December 9, 1909. During the time this animal was undergoing experiment she suffered several mild attacks, each one followed by apparent recovery. Throughout the entire period of experimentation, she was considered a chronic case of the disease. She was in poor condition July 30, 1913, but no more so than upon several previous occasions. On the morning of August 21 she was found very sick, exhibiting the symptoms of a peracute attack, and died that night. The writer was ill and unable to go there, and no autopsy was performed. From the description given by those who observed her, there is little doubt that she died from the disease under consideration. The other animal was inoculated October 17, 1912. She was found dead January 30, 1914. An autopsy revealed the usual lesions following an acute attack. During the period of experimentation her appearance resembled chronic cases which occur naturally.

The time which elapsed between the inoculation and death of these animals renders it difficult, if not impossible, to decide whether they died as the result of inoculation. That may have been the case. On the other hand, it is equally possible that they contracted the disease naturally.

A study of this disease should be continued, over many years if that should prove necessary, until its etiology is determined and it is brought under control. However, the present situation, with a scarcity of material for study and the lack of progress from recent work, renders it questionable whether it should continue as our major problem. It might be a better policy to undertake other work in addition, keeping in touch with this matter, and utilizing such material as becomes available for a continuation of inoculation and therapeutic experiments.

A paper presenting our recent work will be prepared for publication during the coming year.

Hog Cholera

Several outbreaks of hog cholera have afforded further opportunity for demonstrating the efficiency of the Dorset-Niles serum in the control of that disease. We have spent no time in the field this year with hog cholera, but have directed all control work in the State through the

State Quarantine Board. All serum used in the State is supplied through this department. None is furnished to farmers to apply. It is used either by qualified veterinarians in the employ of the State Quarantine Board or by qualified veterinarians in their private practice. When thus employed the results of the use of serum are reported to the board.

We have only success to record with this work. There have been no disappointments. Every outbreak has been promptly suppressed with insignificant losses. We are firmly convinced that this serum, when properly prepared, standardized, and used, will effectually control hog cholera. We hope to publish our experience with the control of this disease by the serum method during the coming year.

Bovine Tuberculosis

The discovery of the existence of tuberculosis in the University herd of cattle was announced in these reports in 1909. The reacting animals were promptly removed from the herd, the more valuable ones kept for breeding and handled according to the Bang system. The herd has been tested at intervals and all subsequent reactors treated in the same manner. All accessions have been given the tuberculin test before entrance to the herd. Reactors have thus sometimes been detected and dealt with accordingly. No reactions have occurred for a long time, and the disease appears to have been completely eradicated from the herd. A continuance of this policy should keep them entirely free.

Chicken Cholera

In March a dead fowl was sent to the laboratory from Goldfield, Nevada, with a request that analyses be made for the detection of poisons. The owner had a flock of from 300 to 325 fowls. In late December, 1913, a few died. The losses subsided after a few days, to reappear about a month later. By the middle of March there were but 170 birds remaining in the flock. There were other losses in the immediate neighborhood. The owners, concluding that they were suffering from malicious poisoning, decided to investigate and sought information regarding the presence of poison in the cadavers.

Autopsy findings indicated infection rather than poisoning. By cultures and animal inoculations, the chicken cholera organism, *Bact. choleræ gallinarum,* was isolated.

The first action was to undertake to stop the outbreak. The premises were clean and had been frequently disinfected by the owner. The birds were well cared for. Apparently more radical measures were essential if the loss was to end promptly. The outbreak was of a comparatively low order of virulence for chicken cholera. It was persisting in spite of disinfection and good hygiene and promised ultimately to destroy the remainder of the flock. Immunization, if it could be secured promptly, seemed the most feasible plan. No vaccines were available. Attenuation of the virus, according to Pasteur's method, would consume considerable time, and the use of living virus, especially if hastily attenuated, is not without danger. Therefore, treatment with killed cultures of the causative organism was undertaken. Suspensions of dead virus were accordingly prepared and 170 birds treated. Apparently the experiment was a success, for the loss promptly ceased.

Reports indicate that chicken cholera is becoming more prevalent

than formerly throughout the country. Adequate measures for the prompt suppression of such outbreaks are needed. While Pasteur successfully immunized chickens against cholera, the method employed by him does not appear to have come into general use. No practicable method is at present available to our poultry owners for the control of this disease. Quarantine and disinfection are generally recommended by our leading sanitarians for its control, but these methods are almost uniformly inadequate and unsatisfactory as well as expensive.

Great advance has been made in recent years in the control of the acute infections by biologic methods. Among these the use of so-called bacterial vaccines—that is, suspensions of dead bacteria—has found a rational place. Undoubtedly this method will be considerably extended in the near future. Active immunity against some of the acute infections can be quickly produced by its use. The method is far more safe than the use of living virus, the proper attenuation of which is a delicate and uncertain procedure. It may prove applicable to the control of outbreaks of chicken cholera. It appears to be worth trial. A series of experiments is being undertaken to answer the following questions:

1. Will suspensions of dead chicken cholera bacteria, when injected into susceptible birds, confer immunity against that disease?
2. What is the duration of that immunity, provided that it can be thus produced?
3. Is this a practicable method for the suppression of outbreaks of that disease?
4. Must such preparations, in order to do the work, be prepared from the particular strain of virus which is causing an outbreak, or can stock preparations be used with equally good results?

Umbilical Necrobacillosis

During the last "lambing season" one of our livestock companies reported a heavy loss of young lambs. A brief investigation was made at their lambing pens. Autopsies were performed upon several lambs of varying ages from new-born to ten days, some of them dead, others moribund and killed for autopsy. In a number of them from two to ten days old, extensive necrotic lesions were found. In those lesions *Bacillus necrophorus* was readily demonstrated.

The initial lesions were in the livers. In some cases the necrotic areas were adherent to adjacent portions of the stomach or abdominal walls or diaphragm, the necrotic process extending into those organs. Further extension from the diaphragm into the adjacent lung tissue was noted. In other cases the lesions were confined to the livers. No lesions were found in lambs less than two days old. The necrotic areas were multiple in all cases observed and varied widely in size. Infection had taken place through the umbilical cords. The cords themselves exhibited no changes, as is usually the case with purulent umbilical infections. Photographs of the lesions were secured and will be used to illustrate a paper describing this outbreak, which is in course of preparation and will be published in the near future.

There were about 4,000 ewes in the lot. They "lambed" about 130%—that is, there were about 5,200 lambs born. With many twins born to an outfit a considerable loss is expected under range conditions, as many ewes are unable to raise twin lambs. However, the loss in this case was far in excess of such expectations; 2,200 lambs died.

Of those the owners estimated that about 70% (1,540) died from this infection.

The necrosis bacillus appears to have a wide distribution in this country. A wide variety of morbid conditions due to infection with it are observed in our domesticated animals. Among them, sheep frequently suffer, oftentimes extensively and severely. While there is a considerable literature on the subject of necrobacillosis, we have found no reference to this particular type of that trouble in sheep. The writer saw one case similar to these in a lamb belonging to the University of Nevada herd in the spring of 1911, but has never described it.

DEPARTMENT OF ECONOMIC ENTOMOLOGY

SAMUEL B. DOTEN

In the summer of 1913, work on the projects of the Department of Entomology made satisfactory progress; but upon the appointment of the entomologist to the directorship of the Station, the work of the department was broken up for several months in the period of reorganization of the Station as a whole.

However, this was not without its benefits. The department had been obliged for years to subsist upon far less money than any other portion of the Experiment Station. The entomologist had worked alone, usually without even a student assistant. The entomological laboratory was incompletely equipped; there was a marked lack of the usual facilities; and progress was made always under a handicap of unnecessary difficulties. After the reorganization the equipment of the department was built up to reasonable proportions. The rooms were refitted, tinted, and painted; office equipment was added, such as filing-cases, indices, and the like. Entomological journals were collected and bound; insect cabinets were purchased, together with collecting apparatus, note books, letter files, a typewriter, and a number of other necessary accessories. A small room for the photographic work of the department was partitioned off and equipped; a basement room for the rougher work of the department was fitted up. Thus, while the department suffered from the loss of time and attention on the part of the entomologist, it profited on the whole from so marked a gain in facilities.

Participation of the Director in Research.

The situation described in the last few paragraphs brings forcibly to the writer's mind the question whether we may not be able finally to achieve such a form of organization as will make possible the necessary general supervision of the Station without depriving the Director of all opportunity for research in his own field of study. This question remained unanswered at the close of the fiscal year.

Still, there are some indications that the answer, when found, will be favorable to research. As has been pointed out elsewhere, everything depends upon the organization of the University as a whole of which the Station is an integral part. If conditions in the University favor research, then it ought not to take the whole time of the Director to administer the affairs of the Station. Provided that his time is not further taken up with extension work, with teaching, or with the detail of departments, he ought still to find time for work in his own field of training. Perhaps this is largely a question of the Station's finding its true field of work, organizing for that type of work, and sticking to that type of work in spite of all the forces which attract or drive the men into other fields.

To the writer's mind the key to the situation is simply this: That the Station drop all those miscellaneous activities which have become almost an inseparable portion of it; that it confine itself to genuine investigations of fundamental things on a basis of scientific experi-

mentation and research. Just as long as the Station is required to do the things which it seemed wise or necessary to do in the past, minor testing, local demonstrations and the like with a host of other activities more closely allied to teaching and extension than to investigation, just so long will it be impossible for the Director to share in the research work of the Station, or to restrict the Station to its best field of work and thought.

Still, the fact of the matter is, in all probability, that the county agricultural advisers and the divisions of extension and demonstration in the agricultural college will take over the miscellaneous activities of the Station and force the latter into its more legitimate field of true investigation. The stations may then lose some of their prestige with their local constituency which they derived from demonstration work and the like; but they will gain standing as research agencies and the universities will gain in reputation and prestige.

It would seem, on the whole, that the possibility of the Director's finding a place in the research work of the Station is a matter purely contingent on the surrounding conditions. It is largely a matter of careful planning of the work long in advance. With the work of the Station carefully planned as a group of related projects, with the projects in charge of highly trained and able men, with a financial system definitely established on a basis of allotments to projects, with ledger accounts opened and kept posted with the projects for the benefit of the members of the staff, with a stable set of administrative conditions in the University, it should be possible for the Director of the Station to spend a satisfactory amount of time in research in his own field. Otherwise, there is going to be little encouragement for the right type of man, the man who has shown some capacity for research, to enter upon the administrative side of the Station's work.

Teaching in the Department of Entomology.

For several years it has been the practice in the University of Nevada not to present definite courses in entomology; but to present instead in the School of Agriculture courses in biology in which insects are treated rather as a part of a great system of plant and animal life than as an isolated set of phenomena. In this way the student gets a view of insect life as a part of all life. Even the Department of Botany, in the School of Agriculture, is largely subordinated to this development of biology. Just as mathematics, the study of quantitative relations, forms the foundation of engineering, just so should biology form the foundation of teaching in agriculture. The center of all teaching in agriculture should be life and its phenomena; for the control of life-processes and relationships of living creatures, plant and animal, is the very essence of agricultural practice. Most fundamentally of all, it is a knowledge of life and its organization and its relations and processes which should be the contribution of the agricultural college to the training of the college-bred farmer. Agronomy and animal husbandry are fundamentally meaningless unless they rest on basic training in biology. Plant and animal physiology, the laws of heredity, reactions to environment in development, form the only basis on which it is possible truly to explain the breeding and rearing of cattle, and the growing of crops. When the work of the School of Agriculture lacks this foundation in biology, then the teaching is not of university grade: it is more like

the rule-of-thumb teaching of a trade school: it is essentially of secondary grade, not of university standard in spirit or in method.

These considerations have led us to make the teaching in entomology primarily a portion of the general work in biology; for agricultural entomology is the study of the life relationships between insect and plant, between insect and insect, between insect and micro-organisms, between insect and bird and mammal.

The European Elm Scale.

For some time our supply of Bulletin No. 65 of the Nevada Station has been exhausted. Meanwhile an experiment in control of the European elm scale, which was planned to run through five years, is still in progress. Our plan has been to perfect and to publish the results of the final tests as a portion of a new edition of the bulletin in question. As these tests have now given perfectly uniform results through four successive years, and as the method is simple, practical, and highly efficient, it is probable that the bulletin will be published in the course of the coming fiscal year, 1914–15. The tests of the last few years, however, have rendered some portions of the earlier bulletin obsolete; and it may prove advisable, therefore, to issue it as a new and later bulletin on the same subject.

Apiculture

Complaints of decreased yields of honey due to the presence of *Thrips* in alfalfa blossoms have come in from time to time from outlying portions of Nevada for several years. Toward the end of the fiscal year 1913–14 preparations were made for the study of this trouble in case of its recurrence in Nevada. The conditions in the Truckee Meadows adjacent to the University of Nevada all indicate a strong probability that there will be ample opportunity for the study of this condition in the course of the coming fiscal year.

Plans are now taking shape for extension work in apiculture, especially in the field of bee diseases, wax moths, and allied bee troubles Because of the great crops of alfalfa raised in the agricultural sections of Nevada, and the presence of sweet clover and other honey plants, there is an excellent opportunity in most of our farming valleys for the production of honey of the highest grade. The introduction of improved methods in the handling of bees and honey will go far toward adding to the profits of the business.

Cutworms Injurious to Alfalfa.

Among the enemies of alfalfa in Nevada are certain cutworms, which from time to time ravage the fields. They are always present in alfalfa fields; usually in numbers so small that they do no appreciable damage. Under certain conditions, however, they become exceedingly abundant. Then, before growth has started in the spring, or just after the hay has been cut, they nip off the young leaves and buds as fast as they appear, and keep the crop down to stubble for weeks. Occasionally this injury is severe enough to cause heavy losses.

Owing to the sporadic character of such outbreaks, the studies now in progress have had to wait until opportunity offered for the examination of ample material. We have had no opportunity as yet for the completion of studies of these pests; and we are now planning to publish certain incomplete studies with a view of adding to them when outbreaks of a serious character shall again occur.

There would seem to be an opportunity in this field for the study of the laws and causes which govern oscillations of these and other destructive species, and for determining the reason why a given caterpillar may suddenly become abnormally abundant and destructive for a season, and then disappear almost wholly for a long period. A study of the relative abundance of cutworms through a long period of years in the same fields with the same controlling factors, together with the life-histories and habits of the species involved, might make material for a project whose results would be of high value.

Hymenopterous Parasites of the Codling Moth.

Studies of certain hymenopterous parasites of the codling moth were continued throughout the year. This project has of necessity become an analysis and study of factors which favor or retard the abundance of these and other hymenopterous parasites. The results are of technical and scientific interest: and for that reason they will not be outlined here. They are soon to be published in bulletin form as a completion of that phase of the work which was first discussed in Bulletin 78, Technical, of the Nevada Experiment Station.

Methods of Rearing and Feeding Hymenopterous Parasites.

These methods were worked out as a minor project in connection with the project mentioned in the last few paragraphs; and they will be presented in the bulletin in which the results of that project are published. They are of interest in other fields of entomology outside the region of hymenopterous parasitism; and for that reason, and some others, will be published and discussed in full detail.

Methods of Photographing Living Insects.

Like the last topic, this one grew out of the work with hymenopterous parasites. For the purposes of that and certain other projects it was highly desirable to illustrate the activities of the insects under observation in the laboratory by means of photographs. This implied from the beginning relatively short exposures to most intense light. Naturally the first work was an adaptation of the usual explosive flash-powder employed in all fields of photography. Good results were gained in this way; but the flash was relatively slow; the smoke was unpleasant in the laboratory; and the synchronization of switch and shutter, when the speed of the shutter was employed, required an electrical mechanism of extreme precision and delicate adjustment.

In the course of the present fiscal year, another form of flashlight was devised in which the incandescent vapor of silver, copper, or magnesium was made the light source. The vapor was produced suddenly by a current of electricity; the duration of the flame was brief; it lasted approximately 1/300 second; for an undetermined reason the flash failed to burn the writer's hand when used with either alternating current or direct.

As the tests of this cold-flame flashlight have many photographic bearings, and as most of the work was done in a way to make the information gained rather broadly applicable, it has seemed advisable to publish the results in full in one of the journals of photography. Thus, through

a fortunate arrangement with Mr. Fayette J. Clute, the editor of Camera Craft, the whole series of results will be published in that journal, appearing from time to time in the course of the coming fiscal year. The purely entomological aspects of the work, however, will be discussed in connection with the forthcoming technical bulletin on Hymenopterous Parasitism.

DEPARTMENT OF AGRONOMY

CHAS. S. KNIGHT

The investigations in agronomy during the summer of 1913 were under the direction of E. A. Howes, Agronomist, and included variety tests of staple crops, the date of planting sugar-beets, and the irrigation of wheat and oats, the results of which are as follows:

Date of Planting Sugar-Beets.

In this experiment the rows were 264 feet long and 33 inches apart, and the plots of three rows each were separated by a four-foot path. The seed was secured from the general supply of the Nevada Sugar Company at Fallon.

Date of planting	Weight (pounds)	Yield per acre (pounds)	Yield per acre (tons)
April 16, 1913	1,390	30,580	15.29
April 23, 1913	1,890	41,580	20.79
April 30, 1913	1,850	40,700	20.35
May 7, 1913	1,565	34,430	17.22
May 14, 1913	1,470	32,340	16.17
May 21, 1913	1,675	36,850	18.42
May 28, 1913	1,360	29,920	14.96
June 4, 1913	1,140	25,080	12.54
June 11, 1913	1,000	22,000	11.00
June 18, 1913	900	19,800	9.90
June 25, 1913	810	17,820	8.91
July 2, 1913	435	9,570	4.79

The results of this experiment indicate that beets planted from April 20 to May 20 will produce the heaviest yields. This particular season included a rather cold, wet spring, which is indicated by the yield of 15.29 tons per acre with beets planted on April 15. The maximum production of 20.79 tons per acre was received from beets planted on April 23. These results indicate the great importance of having all beets planted before the first of June, since after this date a decrease in yield from 12.54 tons to 4.79 tons per acre is noted, the latter yield representing beets planted on the 2d of July.

Variety Test of Potatoes.

The object of this experiment was to compare the yielding power of home-grown varieties with those introduced from other districts. In the test were included twelve varieties of potatoes, which were planted on one-eighteenth-acre plots May 23 and harvested October 15, 1913. The results are as follows:

Variety	Origin of seed	Pounds marketable	Pounds small	Yield per acre in tons marketable	Total yield per acre in tons
Early Red	Red Rock, Nevada	573	103	5.16	6.08
Early Ohio	Minnesota	537	70	4.83	5.46
Early Russet	Minnesota	948	120	8.53	9.61
Great Divide	Washoe, Nevada	1,090	115	9.81	10.85
Irish Cobbler	Minnesota	548	125	4.93	6.06
Carmon No. 2	Minnesota	715	88	6.44	7.23
Algoma	Minnesota	652	105	5.87	6.81
Rural New Yorker	Minnesota	455	114	4.10	5.12
Burbank	Red Rock, Nevada	634	284	5.71	8.26
Peerless	Red Rock, Nevada	868	157	7.81	9.23
Goldcoin[1]	South Dakota	400	121	3.60	4.69
Improved Rose[1]	South Dakota	297	73	2.67	3.33

[1]Planted May 29, 1913, due to delay in shipment.

The results of this experiment favor the home-grown seed, Great Divide being the heaviest producer with 10.85 tons per acre. The three heaviest producing home-grown varieties averaged 9.45 tons in comparison with an average yield of 7.88 tons per acre for the three best producers of the introduced varieties.

Variety Test of Mangels and Swedes.

These varieties were planted on May 3, 1913, in plots of one-twenty-second of an acre. The seed of each variety was secured from Toronto, Canada, with the exception of Ideal Golden Tankard mangel, which was obtained from Waterloo, Ontario.

Variety	Yield in pounds	Yield per acre in tons
Mangels—		
Yellow Globe	1,710	18.8
Golden Tankard (Ideal)	2,530	27.8
Yellow Intermediate	2,270	25.0
Long Red	1,685	18.5
Royal Giant Sugar	2,465	27.1
Swedes—		
Selected Purpletop	1,985	21.1
Canadian Gem	1,995	22.0
Jumbo	1,880	20.7
Hartley's Bronze Top	2,410	26.5
Kangaroo	1,875	20.6

NOTE—Four varieties each of carrots and field turnips were included in this field test of root crops, but proved a failure on account of excessive rain on the heavy soil and the injury from lice and other garden insects and root diseases.

The Ideal Golden Tankard mangel was the heaviest producer with 27.8 tons per acre, while the Royal Giant Sugar mangel was second with 27.1 tons per acre. Of the swedes, Hartley's Bronze Top was the greatest yielder with 26.5 tons per acre. These results indicate the possible yields where mangels and swedes are grown as an addition to the finishing ration for stock.

Variety Test of Corn for Ensilage.

On account of the late spring frosts it is seldom possible to mature a crop of corn at the Experiment Station, although by planting hardy varieties it is possible to obtain a heavy tonnage of forage, which makes a very desirable ensilage. Nine of the hardiest varieties that could be secured were included in the test, one-eleventh of an acre being devoted to each. The corn was checked in hills, three feet apart, May 26 and harvested September 30, 1913. Due to the irregularity in soil conditions, these varieties were duplicated, with the following average result:

Variety	Yield in pounds	Yield per acre in pounds	Yield per acre in tons
Huron Dent	2,005	22,071	11.03
Minnesota No. 13	2,050	22,550	11.27
Sure Crop	1,965	21,615	10.81
Northwest Dent	1,630	17,930	8.96
Pride of Minnesota	1,985	21,835	10.92
Minnesota King	1,470	16,170	8.09
Improved Leaming	2,345	25,795	12.90
Pride of the North	1,960	21,560	10.78
Wisconsin Yellow Dent	1,687	18,562	9.28

In this test Improved Leaming was the heaviest yielder with 12.9 tons per acre, while Northwest Dent gave the lowest yield of 8.09 tons per acre. Alfalfa is used chiefly in this State for forage and ensilage, and 5 tons per

acre is a good average yield. These results indicate that corn may be grown for ensilage with more than double the production of forage per acre.

Variety Test of Cereals.

Three varieties each of wheat, oats, and barley were planted in one-tenth-acre plots on April 15, 1913, using 75 pounds of wheat, 80 pounds of oats, and 90 pounds of barley per acre, with the following results:

Variety	Date of harvest	Yield in pounds	Yield per acre in pounds	Yield per acre in bushels
Marquis wheat	August 14	198	1,980	33.00
Defiance wheat	August 20	252	2,520	42.00
Red Fife wheat	August 20	205	2,050	34.17
Swedish Select oats	August 14	178	1,780	29.67
Regular Abundance oats	August 14	243	2,430	40.60
American Banner oats	August 14	209	2,090	34.83
Manchuria barley	August 8	225	2,250	37.50
Chevalier barley	August 8	225	2,250	37.50
Oderbrucker barley	August 2	220	2,200	36.67

Of the three varieties of wheat Defiance was the best producer with 42 bushels per acre; of the oats Regular Abundance with 40.6 bushels per acre, and of the barleys Manchuria and Chevalier each producing 37.5 bushels per acre.

Irrigation Experiment With Wheat and Oats.

A four years' experiment on the different rates of irrigation with White Australian wheat and Siberian oats was completed. In this test the grain was planted on one-fifth-acre plots, and the object of the experiment was to determine the effect of the time and number of irrigations on the yield of wheat and oats. The irrigations varied from three before and two after heading, two before and three after, to one before and one after. The following table shows the amount of water applied, the yield per acre, and the yield per acre-foot of water:

SIBERIAN OATS

Averages for four years, 1909 to 1912, inclusive

Section	Irrigations		Average total depth applied	Average per acre in bushels	Yield per acre-foot water, in bushels
	Before heading	After heading			
1	3	2	1.810 feet	52.37	29.0
2	3	1	1.550 feet	52.32	33.8
3	2	3	2.092 feet	61.45	29.2
4	2	2	1.843 feet	52.42	28.2
5	2	1	1.331 feet	52.65	39.4
6	1	3	1.682 feet	56.42	33.9
7	1	2	1.407 feet	56.17	40.2
8	1	1	1.007 feet	46.40	47.0

The results of this experiment indicate that the greatest production was received with two irrigations before and three after heading, while the heaviest yield per acre-foot of water was obtained with one irrigation before and one after heading. The yields per acre of oats of over 56 bushels with one irrigation before and two or three after heading also indicate that the oat crop can better withstand a slight shortage of water before than after heading.

WHITE AUSTRALIAN WHEAT

Averages for four years, 1909 to 1912, inclusive

Section	Irrigations		Average total depth applied	Average per acre in bushels	Yield per acre-foot water, in bushels
	Before heading	After heading			
1	3	2	1.966	38.79	21.09
2	3	1	1.825	36.45	28.87
3	2	3	1.794	39.39	23.20
4	2	2	1.383	43.22	33.22
5	2	1	1.283	38.18	30.67
6	1	3	1.438	40.15	29.14
7	1	2	1.266	37.96	29.76
8	1	1	1.000	30.38	34.49

The greatest production was received with two irrigations before and two after heading. The heaviest yield per acre-foot of water was obtained with one irrigation before and one after heading. A detailed report of this irrigation experiment with wheat and oats will occur in a later bulletin.

1914 PROJECTS

Project No. 1.

Subject: This project consists of an irrigation experiment with clover, alfalfa, sugar-beets, potatoes, and wheat, using different amounts of water at each application. With potatoes, sugar-beets, and clover, the water is being applied to the different plots according to the wilting stages of the plants. With wheat different depths of application are being given at the following stages of growth: When five leaves are formed, early boot, bloom, milk, and dough, eliminating one and two periods of irrigations in the different plots; also a comparison of the results of two applications with more than two applications using the same amount of water in each case. The location of this work is at the Experiment Station Farm for field experiments, and in the Experiment Station laboratories for soil and crop analyses. This project was outlined by C. S. Knight, Agronomist, and begun in April, 1914.

Reasons for the Investigation.

The reason for the investigation is to determine the critical stages in the irrigation of each crop and to show at what stages of growth the plants are best able to be deprived of an application of water without causing serious injury to the crops; also to determine the amount of water required for the greatest production and the production with small applications at the different stages. Not only is there a scarcity of water in this State in relation to the area of tillable land that can be placed under ditches, but in most of the valleys too much water is used or wasted in the irrigation of crops to obtain the greatest production and highest quality of products. For this reason it is very necessary to determine at just what stages of growth the staple crops can best be deprived of an application of water.

Points To Be Investigated.

With potatoes and sugar-beets, clover, and alfalfa, a comparative study is being made of the plants at different stages of growth, with different methods of irrigation to determine the proper stages to irrigate these

crops; also the proper amount of water to use at each application for the best results. With wheat the object is to determine at which stage or stages of growth an application of water may be eliminated for the greatest yield of grain; also to determine whether or not two applications of water will prove as efficient to the yield of grain as three or more applications with the same amount of water used.

Plan of Organizing Work or Method of Procedure.

With potatoes aud sugar-beets a comparative study is being made of the plants at different times and stages of growth, with the different methods of irrigation, using two inches, four inches, and six inches of water, respectively, at each application, and applying water to different plots according to the following conditions relative to the plant:

1. Never allowing plants to wilt.
2. Where plants show a tendency to wilt.
3. When all leaves wilt down once.
4. When all plants fail to revive at night.

The following factors will be studied at different times during the growth of each crop:

1. Size of plants.
2. Weight of plants.
3. Water content of plant.
4. Sugar content and purity of beet.
5. Starch content of potatoes.
6. Second growth.
7. Proportion of top to root.

With clover and alfalfa two inches, four inches, and six inches of water, respectively, are being used at each application, the water being applied according to the following conditions relative to the plant:

1. Never allowing plants to show need of water.
2. When plants show need of water by dark color of foliage.
3. When plants show need of water by dark color of foliage and drooping leaves.

The following factors will be studied at different times during the period of growth of these crops:

1. Water content of plant.
2. Weight of individual plants.
3. Yield per acre of forage.
4. Height of plants.
5. Nitrogen content of plant.
6. Number of stems on plant.
7. Number of plants to a given area.
8. The proportion of stems to leaves.

With wheat the following method of irrigation will be followed, using three inches and six inches of water, respectively, at each application:

A. Applying water at different stages of growth, as follows:

1. When five leaves are formed.
2. Early boot.
3. Bloom.
4. Milk.
5. Dough.

In this experiment one period and two periods of irrigation, respectively, are being eliminated in the different plots.

B. Applying water at different stages of growth, as follows:

1. When five leaves are formed.
2. Early boot.
3. Bloom.
4. Dough.

In this experiment the irrigation at the milk stage is being eliminated in all plots and also one other period as above in the different plots.

C. Applying the same amount of water as in B, but giving each plot only two applications of water, one before and one after heading, the object being to show the relative value of applying water in two irrigations with several irrigations.

In this experiment a comparative study is being made of:

1. The amount of tillering or stooling.
2. The thickness of stand.
3. The height of grain at different stages.
4. The nitrogen content at different stages.
5. The yield of forage at different stages.
6. The number of grains on heads.
7. The weight of grains.
8. The yield of grain.
9. The relation of yield of straw to yield of grain.

In this irrigation experiment with the different crops, the water applied to each plot is being carefully measured by running it through iron pipes of a certain size under a given head of water for a given length of time. The head of water is kept constant by having an overflow to other parts of the field, or into the drainage ditch.

Soil moisture determinations are being made at the beginning of the experiment and at regular intervals during the period of growth. Samples of soil are taken from three locations in each plot at each foot in depth down as far as is possible to go with the soil tube, but not deeper than seven feet.

During the experiment and at the close of the growing season a chemical study is being made of these crops, especially of the percentage and purity of the sugar in sugar-beets, starch in potatoes, and the nitrogen contents of wheat, clover, alfalfa, to determine the variation of these constituents under the different conditions above mentioned.

All check plots are receiving the same irrigation as far as possible, and the checks are arranged so that any error which might occur from variation in soil is eliminated.

With sugar-beets and potatoes each plot consists of four rows, with beets the rows being two feet apart and with potatoes three feet apart. The two outside rows of each plot will be eliminated from consideration, in order to prevent any error from lateral diffusion or seepage.

With clover and alfalfa the plots are ten feet wide and with wheat twenty-two feet wide, and as with potatoes and beets the outer portions of the plots are being eliminated from consideration. The clover plots are two hundred sixty-four feet long, while all other plots are one hundred sixty-five feet long.

In these experiments it is the idea to supply sufficient moisture before

and after planting to bring all the crops up and give the same a fair start before beginning the applications of water under experiment. It was found necessary to increase the applications of water with different crops as follows: Potatoes from two, four, and six inches, to three, six, and nine inches, respectively; wheat four and six inches to three and six inches; and clover from two, four, and six inches to six, nine and twelve inches, respectively. These changes were made because three inches of water were required on the wheat and potato plots and six inches on the clover plots in order for the water to reach the ends of the plots.

The irrigation experiment on alfalfa was discontinued for the present year, as it was found impossible to accurately measure the water applied, on account of the irregularity of the alfalfa ground. This work will be included in the next year's experiment, when more suitable alfalfa land will be available.

Project No. 2.

Subject: This project consists of an investigation on varieties of crops and their improvement. The location of the work is at the Experiment Station Farm, Reno, for field work; two farmers in the vicinity of Fallon for cooperative work; and laboratories of the department for a study of the grains and feeds. This project is conducted by C. S. Knight, Agronomist, under the Hatch Fund.

Reasons for the Investigations.

The object of this investigation is to determine the best yielding varieties of the staple crops at the Experiment Farm and test them out in various parts of the State where the altitude and climatic conditions are different. No continuous variety work has been done in this State, and thus there is no available data as to the best varieties for the different localities.

Points To Be Investigated.

Together with the yield per acre a comparative study is being made of the following factors with the varieties of each crop:

Alfalfa: Height of plant, number of stems on plant, and proportion of stems to leaves.

Potatoes: Average number of potatoes in a hill, average weight of potatoes in a hill, and proportion of marketable potatoes.

Corn and Sorghum: Date of tasseling, height of forage, date of ear or head forming, and resistance to early frost.

Wheat, Oats, and Barley: Number of culms to plants, number of grains on head, and height of grain.

Peas, Beans, and Millets: Height and weight of individual plants and resistance to early frost.

Outline of Work.

The first two years will be devoted to a test in rows of all the important varieties of alfalfa, potatoes, corn, sorghum, wheat, oats, barley, field peas, beans, and millets that can be secured; the object being to determine the varieties of these crops which show special adaptation to the existing conditions by their hardiness and yielding capacity, and to improve such varieties by selection ("head to row or plant to row").

When these high-producing varieties have been determined at this station, the object will be to test them out in various parts of the State where the altitude and climatic conditions are different.

The following varieties of each crop are included in this project:

Wheat: Marquis, Medeah, Whitington, White Club, Pellesier, Polish, Gold Coin, Black Don, Sonora, Chul, Fultz, Egyptian Spring, New Zealand, Wisconsin Pedigreed No. 2, Fultz Mediterranean, Colorado Polish, Kubanka, Montana Marquis, Montana Polish, Minnesota Fife, Minnesota Blue Stem, John Brown, Colorado No. 50, Washington Blue Stem, Idaho Marquis, Dicklow, Defiance, White Australian, and Stanley.

Barley: Manchuria, Wisconsin Pedigreed No. 9, G. I. No. 347 Hulless and G. I. No. 652, Poda and G. I. No. 679 France, and G. I. No. 530 South Dakota, No. 682 Heils Hanna, and No. 22303 Two-rowed (Wyo.) Success, Californian, Utah Beardless, U. S. No. 12709, California Feed, Colorado Blue, Colorado White Hulless, Hanna Two-rowed, Scotch Four-rowed, Washington Hulless, Blue Ribbon Two-rowed, Montana White Hulless, Moravian Two-rowed, Silver King, Chevalier, Oderbrucker, White Moravian, Svanbah, Swanneck, Mariont, White Winter or Spring, White Smyrna, Guy Mayle, Hanchen, Oregon No. 19785, Ontario Agricultural College No. 21, Wisconsin No. 6, Beldi.

Oats: Abundance, Black Tartar, Colorado Prows, White Tartar, Sixty Day, Utah Kherson, Sparrow Bill, Danish Swedish Regenerated, Wisconsin Pedigreed No. 1, Wisconsin Pedigreed No. 5, Wisconsin Swedish Select, Great Dakota, Colorado Kherson, Colorado Swedish Select, Colorado Black, Montana Swedish Select, Prince Royal, Storm King, Missouri Black, Missouri Swedish Select, Washington Swedish Select, Colorado No. 37, Wyoming White Russian, Minnesota Black, Idaho Swedish Select, American Banner, New Market, Big Four, Lincoln, Garton No. 572, Nevada Swedish Select, Siberian, Shadeland, Shadeland Challenge, and Banner.

Potatoes: Peerless, Early Red, Early Ohio, Early Russet, Irish Cobbler, Carmon No. 3, Gold Coin, Rural New Yorker, Burbank, and Great Divide.

Beets: Fallon Sugar-Beet, Giant Feeding Mangel, Golden Tankard, Mammoth Long Red, and Our Ideal.

Corn: Improved Leaming, Pride of Minnesota, Pride of the North, Sure Crop, Minnesota No. 13, Northwest Dent, Minnesota King, Huron Dent, and Wisconsin Yellow Dent.

Field Peas: Green Canada, Amorita, Idaho White Canadian, Colorado Stock (Mexican), Montana Marrowfat, Bangalia, Idaho White Marrowfat, Colorado White Canadian, Colorado Stock, Colorado White Marrowfat, Black Eye Marrowfat, Charleton No. 12887, Swiss, White Colorado, Blue Prussian, Tangier.

Soja Beans: Lucas Nos. 305, 504, 604, 605, 702, 902, 1003, 1004, 1202, 1301, 1401, 1501, 1601, 1701, 1801, Ito San, Sable, Mongol, Missouri Ito San, and Horse Bean.

Sorghums: Evergreen Broom Corn, Dwarf Broom Corn, Red Kafir, White Kafir, Dwarf Black Hulled Kafir, Medium Yellow Milo, Straight-necked Milo, Feterita, Shallu.

Millets: Common, Golden, German, Siberian, Hog, Pearl, and Early Fortune.

Alfalfa: Nevada Nos. 1, 3, 5, 6, 7, 14, 15, 16, 19, 20, 27, 35, 38, 56, 58; Argentine Nos. 3507, 3508, 12549, and 13769; Germany Nos. 21217, 22467, 24635, 25194, 25257, 2564; France Nos. 21195, 12694, 12695, 19522, 21187, 22417, 23447, 24758, 24938; Australia Nos. 23753 and 23752; Turkey Nos. 19822, 25932, 16508, 26130; Turkestan Nos. 34 and 22790; Spain Nos. 27397, 27377, 27376, 27372, 27371, 27367, 27365, 22784, 17992; North Dakota Nos. 27250, 27247, 27246, 27245, 27244, 27237, 27234; Kansas Nos. 26642, 24859, 23659, 19508 (Sand Lucerne); Washington No. 16400 (Media); Colorado No. 21022; Punjah No. 29140; Soudan No. 25019.

DEPARTMENT OF CHEMISTRY

C. A. JACOBSON

In the fiscal year 1913–14 work in this department was confined solely to three projects, two of which have been under my direction, and the third under the direction of Dr. Maxwell Adams.

Project I—Alfalfa Investigations. This embraces an investigation of the organic constituents of alfalfa with a view to learn and control the processes involved in the fixation of atmospheric nitrogen by this class of plants.

Various constituents of alfalfa have been isolated and characterized and references to the technical literature covering these investigations were given in last year's report. Additional work along this line was carried on; and a division of it, namely, that of the enzymes present, was completed. A full account of the work on the enzymes present in the dried alfalfa stems and leaves, in the fresh plants and fresh roots, has been published in vol. 36, page 2170, of the Journal of the American Chemical Society. This work was a continuation of that started in Prof. S. G. Hedin's laboratory at Upsala, Sweden, on the enzymes in alfalfa seeds. Individual enzymes were not isolated from their media nor studied in minute detail; but they were characterized by well-established methods, and in several instances were determined with a fair approximation of the amounts present in the various plant extracts.

In reviewing this work, it is well not to lose sight of the fact that, although an enzyme is a chemical compound and not a substance possessing organic or cell structure, neither its chemical constitution nor even its empirical formula has ever been determined with any degree of exactness. Enzyme combinations with complex organic radicals have been made and these enzyme compounds again decomposed with the regeneration of the active enzyme, but such investigations have led to no further conclusions than that the molecular weight of the enzyme must be very large.

The following table sets forth the results of the enzyme investigations, and this portion of the work on Project I can be considered concluded:

Enzyme	Dried plants	Fresh plants	Fresh roots	Seeds
Lipase	—	+ (s)	—	—
Amylase	+ (s)	+ (s)	+ (s)	+
Coagulase	—	+	+	+
Emulsin	+ (l)	+ (l)	+ (s)	+
Invertase	+	+ (s)	+	—
Peroxidase	+ (s)	+	+ (l)	+
Maltase	—	-------	-------	-------
Lactase	—	-------	-------	-------
Pectinase	+ (l)	+ (l)	+	-------
Protease (peptonizing)	—	—	—	—
Protease (peptolytic)	+	+	—	+

The presence of the enzyme is denoted by plus and the absence by minus. The (s) after the sign denotes in small amount and the (l) in considerable or large amount.

It was learned that a slight alkalinity favors the digestion of a casein by the protease present, while an acid medium, above that produced in the normal extract, retards the proteolytic action. Egg albumin was not

digested by the proteases in any portion of the alfalfa plant. In other words, the protease present was not a peptonizing one. The diastatic power of the water extract of the dried alfalfa plants was determined and found to be approximately twenty.

No further work was carried out on Project I, excepting the collection of a great deal of crude material from the alcoholic extracts of alfalfa hay, to be used during the coming year in our investigations of the saponine present in the plant.

Project II—Poisonous Plants. Project II, being an investigation of the local poisonous plants, received the major portion of our attention during the past year; and one phase of this work, namely, the investigation of the poisonous principle in water hemlock, has been completed. This investigation has not yet been published; but the experimental work, with the exception of some molecular weight determinations, has been completed. At the beginning of the investigation we did not have the remotest idea that the work would be as difficult and complicated as it proved to be. A few months of preliminary work had been done on this substance the year before, but not sufficient to give any insight into the complexities that were confronting us.

Water hemlock, known locally as poison parsnip, and botanically as *Cicuta vagans* or *Cicuta occidentalis*, is an umbelliferous plant growing along ditches and on marshy ground. It grows from a rootstock or rhizome which generally attains the size of a hen's egg and is located just below the surface of the ground. This rootstock is renewed every season and grows from the partly decomposed rootstocks of the previous season. It may also develop from seeds, though I am inclined to think that this is not so common. If a fresh rootstock is cut in two, upon the cut surfaces will be seen a yellowish, resinous exudate forming, which soon turns reddish in color. This is the poisonous principle of the plant which has been characterized as a typical resin, and not an alkaloid as was formerly supposed. It has the following empirical formula: ($C_{19}H_{25}O_3$), showing that no nitrogen is present in the compound, By examining a long series of decomposition products and compounds obtained from the substance, we were able to ascribe to it a constitutional formula with a fair degree of probability.

Among its decomposition products are oxalic acid, isobutyric aldehyde, acetyl-2cyclo pentanone, formyl-2cyclo hexanone and an essential oil of the composition ($C_{14}H_{21}O$).

For a detailed discussion of these products and their bearing on the constitution of the cicutoxin molecule, reference must be made to the technical publication which will soon appear. The poisonous principle in water hemlock has been termed cicutoxin by a Russian chemist, and, since the name has been woven into the chemical literature of the subject, it would hardly seem justifiable to change it, although the name has no chemical significance.

The physiological properties of the poison, the lethal dose for rabbits, cats, and guinea-pigs, its stability, physical and chemical properties, and the nature of its decomposition products have been investigated and will be discussed in a forthcoming technical bulletin.

Project III—Pine Oil Investigations. This is an investigation into the character and the quantity of the oil obtained from certain local varieties of pine carried on under the direction of Doctor Maxwell Adams.

During the past year he has investigated the terpenes contained in *Pinus Monophylla* and *Pinus Jeffryii* in Professor Wallach's laboratory at Göttingen, Germany. The volatile oil from the latter species is chiefly normal pentane and not a terpene at all. This work clears up a number of conflicting statements made by Blasdale, Sadtler, Samuels, Schorlemmer, Wenzel, and others regarding the occurrence of normal heptane.

The volatile oil from *Pinus Monophylla* was found to contain 85% pinene, 5% pine, and 2% cadanine.

An article was published in the May issue of the Journal of Industrial and Engineering Chemistry, vol. 6, page 378, on the character and yields of the oil when distilled under diminished pressure. Work on terpenes, found in western pines, is being continued.

Laboratory Equipment.

The Department of Research Chemistry has had the assistance of Mr. August Holmes, who was appointed in July of last year, and has given full time to the work. We have had the further assistance of Mr. Albert Jackson, a student of the University, who has been a general helper in the laboratory to the extent of fourteen hours a week. The department has received substantial aid in the form of improvements and equipment during the past year.

The Food and Drug Department, formerly occupying the Station Laboratory in chemistry jointly with us, was moved to the Physics Building. This greatly relieved the congestion and gave space for mounting important pieces of apparatus. Mr. Dinsmore's former office was remodeled and furnished as the office of the Department of Research Chemistry. Among the added furnishings are office desk and chairs, library table, two bookcases, and two filing-cabinets. In addition to this, one ten-foot apparatus cabinet and one stock-case have been procured.

Chemicals and apparatus, amounting in round numbers to $2,000, have been provided. Among the important pieces of apparatus may be mentioned a centrifuge, a stationary Kjeldahl distillation apparatus, an oil vacuum pump, a wave-length spectrometer, an electric oven, a transportable transmission apparatus, and a Ruhmkorff induction coil.

The laboratory may now be considered well equipped for biochemical research such as that outlined under Projects I and II. A small room, formerly occupied by the Food and Drug Department, has been remodeled and fitted for a physical chemical laboratory, which has also been used as a combustion room.

Soil and Water Analysis.

Mr. Silas E. Ross has been engaged to do the commercial soil and water work of the State, which formerly went to Mr. Dinsmore. Mr. Ross reports the following analyses for the year:

Complete soil analyses	26
Partial soil analyses	18
Mechanical soil analyses—Alkalinity	58
Mineral analyses of water	10
Sanitary analyses of water	29
Irrigation analyses of water	5
Special analyses of water	4
Total	150

Books.

The department has acquired a number of valuable reference books bearing on its type of research; but there are still several important

books and sets of publications which we ought to have in our possession, in order to make our work more effective: namely, Liebig's Annalen der Chemie, volumes 1 to 400, listed at $1,000, Biochemisches Zeitschrift, volumes 1 to 47, listed at $135, and Hoppe Seyler's Zeitschrift fur physiologische Chemie, volumes 1 to 58, listed at $175. With every year these back numbers of the journals are becoming rarer and more expensive, and I recommend that they be procured at the earliest possible date. In the past we have been obliged to resort to loans of these books from the University of California and the Congressional Library at Washington.

DEPARTMENT OF HORTICULTURE

P. B. KENNEDY

Observation and investigation along horticultural lines in Nevada for a period of about twelve years leave one with the impression that Nevada should not attempt to outrival her sister States in the production of perishable fruit products. This does not mean that fruit should not be grown, but simply that the conditions governing the markets, such as transportation, population, and climate, are against the possibility of cheap production. The labor problem is also a difficult one and its high cost prevents the production of fruit for canneries. That excellent fruit of many kinds can be raised is admitted, but the regions where it would be profitable to raise fruit on a commercial scale are few and limited in area.

That a few persons do raise one or two acres of fruit successfully and with a profit by selling to the local market, is no guarantee that hundreds of others could do likewise.

The common fruit diseases have to be fought and in addition the fighting of frost must be undertaken in most localities, at best very expensive and inconvenient types of farm operations.

The same agencies that prevent Nevada from becoming a great fruit-growing State become the chief reasons why farmers should grow their own fruit. The cost of transportation in many instances to remote interior regions in Nevada is prohibitive, It is frequently a case of dried fruit or no fruit at all, unless it is raised close at hand.

This brings me to the point of what phases of horticultural investigation should the Experiment Station carry on that would be of most benefit to the State. In my opinion, it should be along the line of the home orchard, its care, irrigation, pruning, spraying, and the best varieties for use in the home for all purposes. These various factors entering into the care and welfare of the orchard may be made simple demonstration experiments, or they may take the form of research investigations to determine the nature of the climate and soil and other influences, which increase or retard any given fruit crop.

As suggested in my reports for a number of years, a horticultural survey of the State should be made by visiting as many ranches in each county as possible, and particularly those in unusual localities, perhaps high up in the mountains and far removed from the railroad. It is isolated ranches of this kind that will bring together a number of conditions not generally known, and understood in horticultural science. The growing of almonds successfully for a number of years in Hermit Canyon, in the Virginia Mountains, near Reno, is an example. The scientific facts in connection with the growth of such a product, not generally considered a possibility in a region of numerous early frosts, are not known. Theoretically, we believe that topographical features in this particular canyon make the growing of almonds a possibility by causing a continuous current which prevents the settling of the frosts, but there may be other reasons, and at least none have been proven or demonstrated.

The average real-estate man would argue that because almonds grow

in that canyon the whole mountainsides could be planted to almonds, and a new and flourishing industry established. This might be true, but we would have nothing on which we could base our recommendations if called upon for information.

The point we wish to make is that the University of Nevada should have on file all the various conditions of soil and climate and of kinds of fruit now being grown successfully in the State.

The causes which make for success or failure under these conditions would provide unlimited scope for research, and the facts already known would aid materially in advising newcomers, who desire to settle in Nevada.

The survey would suggest many problems, the most important of which would probably be the breeding of varieties to suit the conditions and the introduction of others from parts of the world with a climate and elevation similar to that in Nevada.

The orchard now on the Station Farm is chiefly valuable for instruction in horticulture in the College of Agriculture. It could be utilized for practicums in pruning, spraying, grafting, cover-crops and all other features in connection with a general course in horticulture. The character of the orchard should be changed so as to include as large an assortment of all kinds of fruits as the climate will permit.

To continue to maintain it as an experimental orchard under the Hatch or Adams Funds would be unwise. If for no other reason, its close proximity to the town makes any records of production extremely doubtful. The cost of patrolling a small orchard night and day is greater than the Station funds will permit.

Until suitable land could be secured for an experimental orchard, the work could be carried on in cooperation with several good farmers, the Station maintaining the orchard, and the farmer getting the fruit for the use of the land. The cooperation must be of such a nature that the Station has full control of all cultural operations.

The southern part of the State, especially the Las Vegas and the Moapa Valleys, will have to be regarded as a distinct horticultural section with different problems and possibilities along horticultural lines.

Whether the State continues to maintain a separate experimental farm in the south, or appropriates money to the main station at Reno for the purpose of investigation in the south, will make little difference. Our view of it would be to appropriate a certain sum of money for a given investigation and have the Director of the Station secure some one to conduct the work under his general supervision. The time and money necessary for the general station staff at Reno to carry on lines of investigation in the south is too great, besides seriously interfering with any research experiments.

The settlers in the south, however, have a right to have and do need aid in the conducting of their farm operations so as to bring about the best results. Problems of disease, alkali, irrigation, rotation, and insect pests confront them at all times. The problems needing the most attention should be submitted to the Legislature, and an appropriation made for their investigation under the supervision of the Director. If the difficulties are of such a nature that advice and not investigation is what is needed, then the matter should be handled by the Extension Department of the College.

PLATE I—Hemp (Cannabis Indica) with Young Wormwood in Foreground.

Common Hemp as a Medicinal Plant.

The common hemp has been in cultivation in many parts of the world as a fiber plant for a long time. It is an annual shrub, six to fifteen feet high, belonging to the same family as our common stinging nettle. Although many botanical names have been given to it, supposing that there were a number of different species, they have been found to be incorrect. They are all one and the same plant, whether it is grown for fiber or seed or medical purposes, In medical works, it goes under the name of *Cannabis indica*. Its true name is *Cannabis sativa*. As with all plants that are grown commercially in different parts of the world, it has developed many different varieties or strains which have come to be known after the country which produced them, such as English, Russian, French hemp, etc. Its native home is India and Persia, where it is more highly prized for its narcotic products than for its fiber. Kentucky, Missouri, Illinois, and Minnesota are growers of the plant for fiber purposes, but owing to the introduction of the Philippine Island hemp, a species of banana, and to the large importation of jute, the industry is of less importance. Kern County, California, is known to be able to raise a remarkably fine quality of hemp, which has brought an extra price on the New York market. From Dodge's "Useful Fiber Plants of the World," we learn that hemp was largely employed in the United States for small twines, cordage, and binding twines. He states that it is not a very exhaustive crop and that it will grow on light or heavy soils.

With this introduction, we will proceed to relate something about its medicinal properties, which are not so well known.

The cool climate, which is most suitable for the production of the best fiber, will not develop the medicinal properties. The plant is diœcious, the botanical term for plants which produce the male organs containing the pollen on one plant and the female organs or seed-bearers on another. In growing hemp for medicinal purposes, the least amount of seed possible is desired. For this reason the male plants must be pulled out before the stamens are allowed to ripen and produce the pollen, which would fertilize the female plants. The drug is prepared from the unfertilized blossoming tops of the female plants. The reduction of the seeding process to a minimum allows for the greater development of the active resinous exudation.

In order to determine what this plant might do under Reno conditions, some seed was kindly sent to us by Dr. Rodney H. True of the Bureau of Plant Industry, Washington, D. C. The seed was planted in rows five feet apart in the late spring of 1913, on rich but heavy ground. It came up quickly and thickly after the first irrigation and grew with great rapidity, seeming to enjoy the strong Nevada sunshine. No clue could be discovered while the plants were young as to which might be male or which female plants. But when all were about three feet high a slight difference could be seen in the character of some of the plants. The less robust and slender-stemmed ones proved to be males.

As we had sown the seed too thickly, we had far more plants in the rows than we could allow to remain, so that thinning was resorted to, leaving the plants about two feet apart.

A row of these discards were planted out, which grew fairly well, but never quite caught up with the others. They may be seen in the illustration directly in front of the figure.

The low plants directly in the foreground, looking something like rows of potatoes, are plants of the common wormwood of the old world, *Artemisia absinthium.* We have something to say concerning this in another part of this report.

When the hemp plants were between five and six feet in height, they began to give off a skunky odor, and the tops to be covered with a sticky exudation. These are supposed to be the indications when the plant is ready to be harvested. The tops were cut off about a foot in length and dried in the shade. It is then customary to sack up the material and put it away for storage until sold. The purchase price depends upon the activity of the drug in comparison with the imported article. As this test has to be made by an animal physiologist, we have been unable to find out the quality of our product as grown here in Nevada. We are sending two sacks of it to Dr. Rodney H. True, in charge of drug plant, poisonous plant, physiological and fermentation investigations at the Department of Agriculture, Washington, D. C., in the hope that he may be able to ascertain its value.

From the National Standard Dispensatory, we learn that much of the *Cannabis indica* in the market has lost a large amount of its medicinal virtue, and cannot be relied upon. For this reason it recommends that physicians should always employ a preparation that has been physiologically tested.

We find the action and uses of the drug so interesting that we are tempted to quote them:

"*Cannabis indica* is one of the most extraordinary drugs in the Pharmacopœia. Small doses of it are capable of producing severe and even alarming symptoms; yet, so far as we know, no case of death from an overdose of it has been reported. The drug is also extraordinary by reason of the great susceptibility of some persons to its influence, and the great insusceptibility of other persons to its effects. These effects also vary largely with the individual, and in this respect it somewhat resembles alcohol, since its intoxication may be accompanied by hallucinations, by dreams, by pugnacity, by motiveless merriment, or maudlin emotion. Perhaps its most extraordinary effects is the sensation of prolongation of time which it produces. Under its full influence the pupils are dilated and the patient is usually in a deep sleep. Upon the general nervous system it acts as a distinct sedative.

"Under the name of *haschisch* it was taken by members of a Persian sect, the individuals of which under its influence ran amuck, killing or wounding every one in their path. In the Anglo-Saxon, this homicidal mania is not developed by the drug. The habitual use of *Cannabis indica* in excessive doses causes mental and nervous deterioration, with weak and tremulous limbs. Sometimes the *Cannabis indica* leaves are smoked.

"*Cannabis indica* finds its chief use in medicine as a sedative for distressing cough, the drawback being that many cases of phthisis are susceptible to its cerebral effects. Combined with full doses of gelsemium, it is also largely employed for the relief of migraine and neuralgic headache. Many gynecologists also use it for its sedative influence in pelvic neuralgia, and some even assert that it has an effect upon uterine subinvolution."

Many other products are mentioned as being made from this interesting plant.

PLATE II—Wormwood (Artemisia Judaicum) on Station Farm.

The present market price for the pressed herb is from $1.50 to $1.65 per pound. From two rows sixteen rods long, we harvested about eighty pounds. An acre should produce a crop valued at from $1,000 to $3,000. As the herb sold on the drug market is almost all imported, the possibilities of growing the crop in the United States is well worthy of our attention.

The fact that the seed was sown June 10 and the herb harvested on September 27 indicates its rapid growth. The amount of labor involved is no more than is required for ordinary cultivated crops. The seed is quoted at 6 cents a pound.

Wormwood (Artemisia Absinthium).

Wormwood is a common garden herb belonging to the family Compositæ and closely related to the common Nevada sagebrush. Its usefulness for medicinal purposes has long been known and especially also as a vermifuge.

The plant is almost shrubby, growing from two to four feet high, spreading perpendicularly with many branches. The stems and leaves have a grayish-white silky appearance with numerous clusters of yellowish-green flowers on the ends of the branches.

The seed was sown in a frame early in spring, when numerous plants came up in a month and were ready to transplant to the field by June. The distance between the rows was two feet and the plants placed six inches apart in the row. Even though it was very warm weather, by careful irrigation practically all the plants survived.

By fall the plants reached a height of eight inches (see illustration) without sending out any flowering stems and remained in this condition all winter. It proved perfectly hardy and continued to grow rapidly the next year, attaining a height of several feet, as shown in illustration. The same results could no doubt be secured by sowing directly in the field and thinning out, as it is a hardy plant.

A bitter extract is obtained from this species, as well as from *Artemisia judaicum*, and called absinth. Of this liquor millions of gallons are used in France and to some extent in America. It has an exhilarating effect, but its continuous use brings about a gradual decrease of the intellectual faculties, ending in delirium and death. The French government has prohibited its use in the army and navy. Its use probably dates back to biblical times, as we read in Jeremiah: "He hath made me drunken with wormwood."

In China a form of camphor used in the manufacture of India ink and which is the cause of its peculiar odor is made from a species of *Artemisia*.

Another native species of China (*Artemisia chinensis*) is used to produce a blister by burning small pellets of the dried plant on the skin.

Another European species has proven itself useful for windbreaks in the Canadian Northwest.

Tarragon, a native of Siberia, and cultivated in our gardens as a culinary herb for flavoring dishes, is a species of *Artemisia Dracunculus*.

Artemisia absinthium, *A. martima*, and *A. pontica*, are all aromatic, intensely bitter and in great repute as a vermifuge, and to prevent moths and other insects from infesting clothes and furniture. They are also sometimes used as a substitute for hops.

The question naturally arises why could not our Nevada species, *Artemisia tridentata*, be found useful for camphor or as a vermifugè. It seems to have all the external properties of the other species.

Native and Introduced Clovers in the United States.

This work formerly carried on by me at the University of Nevada has been transferred to the University of California through the kindly cooperation of the officials of both institutions and the Office of Experiment Stations at Washington, D. C. The monograph will include the morphology, distribution, classification, nomenclature, and economic importance of all species of the genus *Trifolium* in the United States. Each species is studied from seed to maturity and full illustrations made of all the species. The drawings for Nevada were executed in a very satisfactory manner by Mr. L. T. Shannon, a student in the University.

Seven preliminary papers have been published in the botanical journal *Muhlenbergia* entitled "Studies in *Trifolium*." The eighth paper discussing the section *Physosemium*, an interesting group with inflated corollas, will soon be ready for publication.

Progress is slow on account of the small amount of time that can be spared for the work and the large amount of detailed study necessary to find the natural variations within a given species. The slightest variation in soil or moisture will often produce pronounced morphological characters. In fact, a series of specimens taken from a wide range contradict the original description so widely that almost every local variation has to be described separately if the forms collected are to be included. The characters are not of sufficient importance to base species on, and yet they must be recognized.

DEPARTMENT OF METEOROLOGY

J. E. Church, Jr.
S. P. Fergusson

The activity of the Department of Meteorology during the year has been confined to the following projects:

(1) Forecasting Frost from Summits of Mountains;
(2) The Study of Snow; and
(3) The Temperature Survey of the Agricultural Lands of Nevada and Experiments in Orchard Heating.

(1) Forecasting Front from Summits of Mountains.

During the year continuous records of temperature, pressure, wind direction, and humidity on Mount Rose (10,800 feet) have been obtained by means of the meteorograph now perfected. Continuous records of wind velocity have also been obtained, but the records obtained during the winter are vitiated more or less by the action of ice and snow feathers which retard the whirling cups of the anemometer.

Continuous records have also been obtained at the base stations at Truckee and Fallon, but unfortunately most of the records made at Truckee were destroyed by the partial destruction of the observer's home by fire.

The analysis of such data as have been gathered since 1910 is now progressing according to the following plan:

(1) A careful comparison of simultaneous records from Truckee, Mount Rose, and Fallon is being made to detect the most obvious coincidences or differences.
(2) The instances where a change of phase or condition occurs are to be studied separately in their relation to other meteorological elements in order to determine the causes of the change.
(3) The relation of changes of condition to the normal diurnal and annual periods of the principal elements will probably be the final stage of the investigation. The diurnal and annual periods are being computed for four months of the year (one for each season) from readings of the automatic records made every two hours, of temperature, pressure, humidity, and, when possible, of the direction and velocity of the wind.

Owing to the necessity of making minor improvements in the meteorographs and designing and constructing apparatus for the prosecution of the other projects, progress in the analysis of the data must necessarily be slow.

(2) The Study of Snow.

The study of snow during the past season has comprised two problems distinctly related to each other:

(1) The Influence of Mountains and Forests on the Conservation of Snow; and
(2) The Forecasting of Water for Irrigation.

Through the generosity of the Board of Control and the Director, continuous observations at Lake Tahoe have been resumed by the former observer, Arthur L. Smith, while periodic observations have been continued as usual on Mount Rose.

Observations on the conserving power of pine and fir forests have been conducted in still greater detail to test the accuracy of earlier observations. Owing to the very heavy precipitation, the data obtained will have an unusual value in determining the relative behavior of forests in conserving deep and shallow snows.

Measurements of the evaporation of snow on the ground under serious conditions of exposure and protection have been carried on with only infrequent interruptions throughout the winter. Annoying breaks in the record, due to the filling up and burying of the evaporation pans by storms, have been largely avoided by placing canopies of canvas over the pans. These canopies have been especially valuable in dense forests where snow sifting down from the trees inevitably falls into the pans.

Special evaporation pans have been devised by Mr. Smith to determine the rate of evaporation of the snow held in suspension by the trees.

The influence of air and soil upon the snow cover has been measured at frequent intervals by the use of thermometers inserted through sampler holes. That the coldest part of the snow cover lies usually midway between the top and bottom of the snow has been noticed both in the deep drifts on the rocks of Mount Rose and in the shallow snow in the forests at Lake Tahoe.

The approximate altitude of maximum snowfall for the Sierra Nevada locally seems to have been established by a snow survey conducted last spring at various elevations above 9,000 feet on Mount Rose and above 8,200 feet on Mount Tallac. However, the conclusions reached should be verified.

Advantage was taken of the great depth of snow encountered last winter to perfect the snow sampler for feasible driving at depths of twenty feet. This has been accomplished by making the sampler lighter, yet more rigid, by making the cutter more tapering and providing it with lateral teeth for breaking up hard snow, and by the use of a wrench upon which the observer can stand and utilize his entire weight in driving. A sampler of this pattern has been made for the Gletscher-Kommission of Switzerland for use in the Alps.

The seasonal survey of the Lake Tahoe Basin, upon which the forecasting of water for irrigation has been based, has now been continued the fourth season. The survey has usually been made in two weeks by two men working together, and the forecast of the level of the lake has been within one- or two-tenths of one foot of the level actually attained, assuming that the dam was not open. The present season two surveys were made, the first one as early as February to settle doubts regarding the amount of snowfall in the high mountains, the second one in April, to quiet apprehension of flood on the part of property owners around the lake. The forecast will probably be five-tenths of one foot above the maximum lake level; for the snow has passed off so slowly that it has been subjected to unusual loss by evaporation, while the evaporation of the water over the surface of the lake has continued unabated.

The value of the forecast is shown by the fact that as early as February assurances could be given the power companies and ranchers that

the scarcity of water that had prevailed during the previous two years would give place to a season of unusual abundance. More exact forecasting will probably require further investigation of the precipitation over the basin and the determination of the loss of water due to evaporation on snow and water surfaces, the ultimate object being finally to reduce the snow survey to the least possible effort.

(3) Temperature Survey of the Agricultural Lands of Nevada and Experiments in Orchard Heating.

The temperature survey of the Truckee Meadows is nearing completion. Two years' data have been tabulated and verify the statements previously made in Bulletin No. 79.

Experiments in orchard heating are being continued at Church's orchard without expense to the department. The results plainly indicate the possibility that orchards in the average fruit-belts of Nevada can be protected at moderate cost. Indeed, the present season all fruit except the earliest would have escaped unharmed, despite the fact that the buds were started one month early by unusually fair weather in the month of March, had it not been for one frost of 26°F. that occurred in April. But, even so, the orchards will bear a fair crop of apples. From the experience of this season it appears that temperatures of 28° to 31°F. may not work commercial injury to unheated orchards.

Publications.

The following papers have been published or accepted for publication during the year:

Recent Studies of Snow in the United States: *Quart. Jour. of the Royal Met. Soc.* XL, 169 (Jan. 1914).

The Retarding Effects of Various Types of Forests on the Sudden Melting of Snow: *Engineering Record,* June 13, 1914.

Snow Survey of the Tahoe Basin, a Study in the Rapid Survey of Large Areas of Snow at High Elevations: *Engineering Record* (to be published).

Keeping the Frost Away from the Fruit: *Farm and Fireside,* Saturday, March 14, 1914.

Forecasts of Water Supply, in the *Reno Evening Gazette* during the winter and spring.

Reprint of the Progress of Mount Rose Observatory (Science, December 6, 1912) in *Jahresbericht des Sonnblick Vereins for 1912.*

Aside from the work of preparing preliminary bulletins on Projects I and II, and performing routine duties, the following plans have been outlined for the coming year:

1. To study tamarack and mountain hemlock forests with reference to the conservation of snow.
2. To continue the study of evaporation of snow and extend it to various slopes.
3. To study the relation of the air temperature to the variations in temperature in snow.
4. To inaugurate a study of the influence of mountain slopes upon the conservation of snow.
5. To perfect, if possible, the method of forecasting the water supply.
6. To extend the temperature survey to other valleys of the State.

7. To prepare an exhibit in Agricultural Meteorology for the Educational Division at the Panama-Pacific Exposition (as requested by Dr. A. C. True), if the necessary funds can be obtained.

The greatest gain of the entire year has been the obtaining of material with which to build a cabin cruiser sufficiently large and staunch to house the observer and carry him to any point on the lake irrespective of weather. This means the carrying on of measurements at distant points by a single party, and brings the various slopes around the lake within easy reach.

It seems fitting in closing to pay a tribute to the memory of President Stubbs, who, with far vision, urged on the work in its infancy, when the observers might otherwise have ceased their efforts, and to thank the Board of Control, and Director S. B. Doten, who helped install the first instruments on Mount Rose, for their generous support of the work.

FINANCIAL STATEMENT

C. H. GORMAN

Nevada Agricultural Experiment Station

IN ACCOUNT WITH

The United States Appropriations, 1913–1914

Items	Abstract	Hatch Fund	Adams Fund
Debit			
To balance from appropriations for 1912–1913		$725.00	$1,483.30
Receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1914, under Acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund)		14,275.00	13,516.70
		$15,000.00	$15,000.00
Credit			
By salaries	1	$6,319.47	$10,918.00
By labor	2	3,102.45	35.45
By publications	3	223.91	(omit)
By postage and stationery	4	334.03	68.60
By freight and express	5	351.68	109.09
By heat, light, water, and power	6	62.00	61.65
By chemicals and laboratory supplies	7	282.93	611.48
By seeds, plants, and sundry supplies	8	634.13	155.34
By fertilizers	9	0.00	0.00
By feeding-stuffs	10	25.00	183.35
By library	11	347.16	110.18
By tools, machinery, and appliances	12	737.32	107.39
By furniture and fixtures	13	1,359.60	90.00
By scientific apparatus and specimens	14	358.19	2,343.87
By live stock	15	8.50	1.00
By traveling expenses	16	175.53	204.60
By contingent expenses	17	20.00	0.00
By buildings and land	18	658.10	0.00
By balance		0.00	0.00
Totals		$15,000.00	$15,000.00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the Nevada Agricultural Experiment Station for the fiscal year ended June 30, 1914; that we have found the same well kept and classified as above; that the balance brought forward from the preceding year was $725 on the Hatch Fund and $1,483.30 on the Adams Fund; that the receipts for the year from the Treasurer of the United States were $14,275 under the Act of Congress of March 2, 1887, and $13,516.70 under the Act of Congress of March 16, 1906, and the corresponding disbursements $15,000 and $15,000; for all of which proper vouchers are on file and have been by us examined and found correct, leaving balances of $0 and $0.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress, approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said Acts, respectively.

(Signed) A. A. CODD,
[SEAL] H. C. REID,
J. W. O'BRIEN,
Attest: (Signed) C. H. GORMAN, *Custodian.* *Auditors.*

PUBLICATIONS OF THE STATION FOR THE FISCAL YEAR 1913-14

S. B. DOTEN, *Director*

Publications of the Nevada Station during the fiscal year 1913–14 fall into two groups: popular publications and technical. Those in the first group are partly reports of the work of the Nevada Station: and to some extent they include reports of the work of other stations, which will be of service in Nevada. For this reason they were not issued under the serial numbers of the Nevada Station: but were published under the title "Better Farming," in compliance with the Nevada state law of the Legislature of 1913.

Popular Bulletins.

The bulletins in the "Better Farming" series were exceedingly well received by the people of the State. The editions were small; and, as a result, some of them are already exhausted. The list of popular bulletins of this series, published in the past fiscal year, is as follows:

Vol. I, No. 4—The Value of Soil Investigations, Alkali Lands, Underground Waters and Alkali, Composting as a Method of Using Organic Waste on a Small Farm.
No. 5—Feeding Dairy Cattle, The Judging of Dairy Cattle, Improving the Raw Product.
No. 6—Poultry Notes.
No. 7—Relation of the Experiment Station to the Agricultural College and to University Extension, Suggestions to Those Wishing Agricultural Literature.
No. 8—Questions and Answers.
No. 9—Irrigation and Some of Its Problems in Nevada.
Vol. II, No. 1—Announcements of Dairy Short Course and Farmers' Week; Breeds of Dairy Cattle.
No. 2—General Information for Sugar-Beet Growers in Nevada.
No. 3—Cooperative Experiment; Books and Periodicals for the Farm.
No. 4—Frost Prevention in Fruit Orchards.
No. 5—The Codling Moth, The European Elm Scale.
No. 6—Poisonous Plants; An Investigation of Clover Dodder.

Owing to the rules covering the use of the Station frank, the "Better Farming" series is no longer issued from the Experiment Station, but has been transferred to the Division of Agricultural Extension.

Technical Bulletins.

As the result of experimental work carried on in its laboratories, each experiment station is certain to develop original and novel methods of work and to get results which at first will be most valuable to scientists trained in special fields of study. Papers dealing with the results of such laboratory researches are published by many of the experiment stations as special "technical bulletins." The Nevada Station for the

past fiscal year preferred to publish its technical material very largely in the journals of various sciences. The following papers, setting forth the results of the work in the Nevada Station, were issued in the journals quoted:

Wood Distillation Under Diminished Pressure. Jour. Ind. and Eng. Chem.

The Conservation of Snow; Its Dependence Upon Mountains and Forests (reprint). Engineering and Contracting, XXXIX. 6.

The Relative Efficiency of Talus Slopes in Conserving Snow for Irrigation. Engineering and Contracting, XL. 16.

Recent Studies of Snow in the United States. Quarterly Journal of the Royal Meteorological Society, XL. 169. (England.)

The Retarding Effect of Various Types of Forests on the Sudden Melting of Snow. Engineering Record, 69, 24.

Das Verhaltniss des Waldes und des Gebirges zur Erhaltung des Schnees. Meteorologische Zeitschrift, XXX. 1.

Das Verhaltniss des Waldes und des Gebirges zur Erhaltung des Schnees (reprinted in part and reviewed). Petermann's Geographische Mitteilungen; Klein, Jahrbuch, XXIV.

The Snow Survey of the Tahoe Basin: A Study in the Rapid Survey of Large Areas of Snow at High Elevations (accepted for publication). Engineering Record.

The Progress of Mount Rose Observatory, 1906–1912 (reprint). Jahresbericht des Sonnblick-Vereins fur 1912 (Austria).

A Mount Rose Weather-obszervatoriumbol (reprint). Az Idojaras, June, 1914 (Hungary).

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AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Annual Report of the Board of Control for the Fiscal Year Ending June 30, 1915

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

CARSON CITY, NEVADA
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
1916

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NEVADA AGRICULTURAL EXPERIMENT STATION

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*Resigned August, 1915.

LETTER OF TRANSMITTAL

To the President and Board of Control, Nevada Agricultural Experiment Station, University of Nevada.

GENTLEMEN: I have the honor to transmit herewith the annual report of the Agricultural Experiment Station for the year ending June 30, 1915.

Respectfully submitted,

S. B. DOTEN,
Director.

FINANCIAL STATEMENT

C. H. Gorman

Nevada Agricultural Experiment Station

IN ACCOUNT WITH

The United States Appropriations, 1914–1915

Items		Hatch Fund	Adams Fund
Debit			
To balance from appropriations for 1913–1914		$0.00	$0.00
Receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1915, under Acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund)		15,000.00	15,000.00
Credit	Abstract		
By salaries	1	$8,992.29	$11,108.83
By labor	2	2,307.18	137.27
By publications	3	70.84	
By postage and stationery	4	300.91	76.50
By freight and express	5	72.87	183.02
By heat, light, water, and power	6	59.05	247.67
By chemicals and laboratory supplies	7	146.72	914.47
By seeds, plants, and sundry supplies	8	457.17	497.43
By fertilizers	9	None	None
By feeding-stuffs	10	26.05	331.36
By library	11	96.69	21.30
By tools, machinery, and appliances	12	908.14	375.25
By furniture and fixtures	13	254.20	413.05
By scientific apparatus and specimens	14	194.73	425.27
By live stock	15	63.50	61.00
By traveling expenses	16	523.25	207.58
By contingent expenses	17	20.00	
By buildings and lands	18	506.41	
By balance		0.00	0.00
Totals		$15,000.00	$15,000.00

We, the undersigned, duly appointed Finance Committee of the Board of Regents, do hereby certify that we have examined the books and accounts of the Nevada Agricultural Experiment Station for the fiscal year ended June 30, 1915; that we have found the same well kept and classified as above; that the balance brought forward from the preceding year was $0 on the Hatch Fund and $0 on the Adams Fund; that the receipts for the year from the Treasurer of the United States were $15,000 under the Act of Congress of March 2, 1887, and $15,000 under the Act of Congress of March 16, 1906, and the corresponding disbursements $15,000 and $15,000; for all of which proper vouchers are on file and have been by us examined and found correct, leaving balances of $0 and $0.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said Acts, respectively.

(Signed) A. A. CODD,
JOHN J. SULLIVAN,
J. W. O'BRIEN,
Finance Committee Board of Regents.

[SEAL]

Attest: (Signed) C. H. Gorman, *Custodian.*

REPORT OF THE DIRECTOR

SCIENCE AT WORK FOR THE GOOD OF AN INDUSTRY

Every growing modern industry feels the necessity of studying by scientific methods the problems which come up in factory, workshop, and field. The Bell Telephone Company, for instance, maintains a corps of 550 experts representing more than 70 American and European universities to investigate the technical problems connected with the maintenance, improvement, and expansion of the telephone industry.

In each of the States the federal government maintains for the agricultural industry the nucleus of such a technical service. In very many of the States the funds supplied by the federal government form only a small portion of the total funds available in the Experiment Station, which is largely state-supported.

To illustrate how the solution of a technical problem may advance an industry, it is only necessary to look at the effect of hog-cholera serum on the growth of the hog business in America. Before the discovery of a successful hog-cholera serum, it seemed as though in parts of America hog-raising would be swept out of existence. In Nevada many farmers became afraid to raise hogs, because of the losses from cholera. Later, up to 1915, the total number raised increased greatly when an effective serum treatment was devised. Further improvements in the serum are needed; and the study of such improvements is in progress in the Nevada Station.

We may fairly expect to have an equally good illustration of the value of experimental work in an increased production of farm crops under irrigation. In Nevada the field and farm type of agriculture is limited by the limits of the water supply. Studies of the actual use and of the best use of water in this State give good reason to believe that in the future the acreage under irrigation in Nevada will be very much greater than it is at the present time. If in connection with studies of the best use of water we determine experimentally the best and most suitable varieties of the leading farm crops, it should be possible to make small tracts of land in the State produce such yields of valuable crops under a limited water supply that they will support a greatly increased farm population. Experimental work now in progress in the University has given the agricultural staff a very hopeful outlook for the future of farm development in the State.

Dry-farming in the most favorable localities, dairying, poultry-raising, hog-raising, the production of berries and other small fruits and vegetables, a great extension of the acreage which can be irrigated with a limited water supply, all alike point to a period of steady and exceedingly substantial upward progress in the agriculture of the State.

It is the duty and the purpose of the Nevada Station to aid in this development by finding solutions, if possible, for the problems which hinder the progress of our agriculture. If in the past there has been less need of experimental work, and if the farmers of the State have not always brought their problems to the University for solution, still

in the future the need will grow rapidly with the development and specialization of agriculture; and the problems coming to the Station will be, as they are even now, so numerous that the federal funds alone will prove insufficient.

In the beginning the United States established an experiment station in each of the States in order that it might give direct assistance to the agriculture of the State in the solution of its vital problems. From this point of view it is evident that the members of the Station Staff—men well trained in the natural sciences and ambitious to succeed—must base their success upon the substantial aid which their scientific investigations give to the farming industry of the State. In the solution of problems by scientific methods it is possible for an experiment station to become a strong force in developing a more profitable local agriculture.

Upon the present Director in the fiscal year 1913–1914 fell the responsibility of developing such a policy for the Nevada Experiment Station. From the beginning the need of making the Station effective as an aid to the agriculture of the State was urged by the members of the Board of Regents. They gave every possible encouragement to the development of projects which promised direct assistance to farming and stock-raising, taking an especial interest in a new series of experiments in Agronomy and Irrigation under Dean C. S. Knight, which aimed to make the best possible use of a limited water supply.

Upon the appointment of President A. W. Hendrick in September, 1914, the effort to make the Nevada Station of greater service to agriculture received a strong impetus. President Hendrick showed a clear understanding of agricultural problems and of the essential purpose of Experiment Station work. He planned to shape the work of the Nevada Station along lines of public service, and he made the Station a part of the public service division of the University, urging the redirection of the experimental work of the Station in a way to make it directly beneficial to Nevada agriculture.

If the peculiar agricultural conditions found in Nevada and the problems presented by Nevada agriculture are taken as the basis for Experiment Station work, then the project work of this Station will represent at least three great groups of problems—the water problem, problems of animal disease, and the range problem. Each year, however, other problems arise in soil and climate, in plant diseases, insect pests, and the like; but they are usually not of such fundamental importance as the problems connected with the use of water, the control of animal disease, the control of poisonous plants, the revegetation of the range. This means simply that the agriculture of the State presents great problems for solution, and in these problems the Station finds its principal field of work. When the work of the Station is based definitely upon problems of agriculture, the field of work of the Station is impersonal and obvious. In setting up the standard of public service, in making an earnest effort to seek and to solve vital problems, the Station is plainly doing the thing which lies next to its hand and is serving the purpose for which it was founded.

THE WATER PROBLEM

First of all, the water problem is of fundamental importance. The immense acreage of good land in Nevada is good land only as water

and cultivation make it so. Dry-farming in Nevada is often precarious, not because of soil conditions, but partly because of market conditions, and more largely because of a deficiency in rainfall. Still, dry-farming is already successful in certain parts of the State; and the development of new dry-farm crops and of improved dry-farm methods may bring a hard-won success in many Nevada valleys.

However, the fundamental farming problem in Nevada, based on our immense acreage and a water supply insufficient to irrigate it all, is this: How can we gain under irrigation the most profitable crop yield with the available water? In Nevada the question of the largest crop per acre of land is less important than the question of the highest crop-value per inch of water. This great water problem—the central problem of Nevada agriculture—will be with us as long as the State exists. Here is a most promising field for helpful experimental work—the study of methods of making our available water supply go just as far as possible in crop productoon.

In this connection the engineering experiments begun recently by Dean J. G. Scrugham of the College of Engineering, University of Nevada, in the development of underground water, are exceedingly interesting and promising. Two kinds of work are needed here for the solution of the water problem—the work of the engineer in the development and conservation of water, and the work of the agronomist in making the water most highly useful in crop production. One of the first things done then in the effort to make our Station work more serviceable was to begin in 1913–1914 a series of experiments under Dean C. S. Knight of the School of Agriculture of the amount of water actually needed by the leading crops grown in the State, of the stages at which irrigation is most important, and of the number of irrigations and the quantities of water actually required. These experiments have now been carried on for two years by Dean Knight and his assistant, Mr. J. B. Menardi, and the work has been done with painstaking thoroughness.

In the course of the fiscal year 1914–1915 a part of the work in mountain meteorology, done by Dr. J. E. Church and his assistant, Professor S. P. Fergusson, has been terminated; because it reached a stage where conclusions could be drawn. The frost-forecasting studies, carried on for many years on the summit of Mount Rose by the Nevada Experiment Station, have been completed and will be published and discontinued in the fiscal year 1915–1916.

Snow studies at Lake Tahoe will be continued through the fiscal year 1915–1916, because of their relation to the water problem. With the assistance of Professor S. P. Fergusson and Mr. Arthur Smith, Dr. J. E. Church, head of the Department of Meteorology in the Nevada Station, has nearly perfected a method of snow surveying by which it is possible to forecast for any given year in the spring the amount of water for irrigation which will be available in the late summer. The perfection of the method of snow surveying and run-off forecasting will help toward the solution of the water problem in the western States. It is the plan of the Experiment Station to publish soon a final statement of the perfected method of snow surveying, based upon a series of surveys made under highly favorable conditions in the Lake Tahoe Basin.

PROBLEMS IN ANIMAL DISEASE

Although climatic conditions in Nevada are very favorable, diseases of live stock are found here just as everywhere else in the world. With the growing cost of meat, leather, and wool, with the corresponding increase in the value of sheep and cattle, and in the importance of the livestock industry, losses by disease have become increasingly important. A few years ago the loss of a few animals amounted to little and attracted little attention. Today the value of live stock is so much greater that the losses are relatively heavier and are highly important.

From all these facts it is very easy to see that one of the most important fields of public service for the Nevada Station is this study of animal disease. For this reason it has been essential in the past fiscal year to increase the allotments made to Veterinary Science and Bacteriology, and to grant that department in the Station a personnel and equipment which would let it give the State the service so much needed in the investigation of animal diseases. Under Dr. W. B. Mack, this department is justifying a generous allotment by proving its usefulness.

The American experiment station system was founded to solve problems and to aid the development of agriculture. The progress of hog-raising in Nevada has been checked by hog cholera. The progress of the poultry industry has been hampered by the disease known as roup, chickenpox, or contagious epithelioma. Improved methods of treating both diseases are being worked out and tested in the Nevada Station. Problems of animal disease press heavily upon the small farmer. In this field under Nevada conditions the Experiment Station is in a position to be of greater assistance to the small farmer than to the heavy owner of live stock. The man with thousands of head of cattle and sheep running at large on the public domain does not feel the loss of a few animals as does the man who has only a small number of stock and a restricted range to which he must look for a substantial share of his profits. The strengthening of the Department of Veterinary Science and Bacteriology in the Experiment Station has met an instant response from the people of the State, who are quick to feel that in this department the University is giving the State an essential public service.

THE RANGE PROBLEM

The third large group of problems plainly evident in Nevada agriculture is found in the condition of the ranges. The overstocking of the range, with the gradual but sure disappearance of valuable grasses and forage plants from the open public domain, has been injurious, even disastrous, throughout the whole West. Nevada has shared with other western States in the injurious effects of overgrazing; though local economic conditions have in many instances established control and prevented to some degree the most severe overstocking. Ranch and range in Nevada are so closely tied together by conditions of market and climate that in many portions of the State a ranch will be almost useless without the adjacent range.

The United States Department of Agriculture gives the following figures for the value of sheep and cattle on Nevada farms and ranches on January 1, 1916:

Cattle	$20,638,400.00
Sheep	8,886,000.00

Their estimate of the Nevada wool crop for 1915 is 5,890,000 pounds, valued at approximately $1,000,000. Figures for 1915 from the same source for staple farm crops are as follows:

Hay	$5,062.000.00
Wheat	1,577,000.00
Potatoes	1,565,000.00
Barley	403,000.00
Oats	322,000.00

The heavy production of hay is due to the fact that large quantities of hay can be marketed profitably in Nevada by feeding it to live stock.

The figures for cattle, sheep, wool, and hay show the importance of the livestock industry in Nevada. Nevada is an enormous plateau, almost the whole surface being ridged with great mountain chains. In Nevada mountains too steep and high for farming, unsuited even for forestry, are usually covered with a more or less dense growth of grasses, low-lying plants and shrubs.

They are sheep and cattle ranges. There is no reason to expect that they will ever be put to better use. In very many of the other western States, the range has been broken up into farms and the livestock industry has changed greatly in its whole form. In Nevada this is not the case and never can be to the same degree, just because so much of our range is not level or rolling country suitable for farming, but hill-range or mountain-range.

Even the valleys of the State are so elevated that climatic conditions restrict the kind of crops that may be grown. The irrigated mountain valleys, however, are admirably suited to the production of hay; the climate of the whole State is very favorable to the production of live stock, for which the hay is used as winter feed. Based upon our sheep and cattle industry we have ranches where alfalfa hay and native wild grass hay are raised in large quantities; ranch and range together forming the foundation of a great and permanent livestock industry.

It is easy to find places in Nevada so isolated that, although favorable local climate and soil conditions make it possible to grow excellent celery, onions, apples, and other relatively high-priced products, still, in such localities, the land must be put into hay and kept in hay year after year, because there is no local market for the other products, and the expense of shipment to more distant markets is prohibitive. Hay is needed for the cattle; and the land yields alfalfa or wild grass hay abundantly. However, under such conditions, only the adjacent range makes even the hay of value, because it is fed on the ranch to animals which go out to market on the hoof.

The great group of problems in restoring depleted ranges is a matter of fundamental importance. The admirable work already done in the University of Arizona, under Professor Thornber, and in the United States Department of Agriculture by Messrs. Jardine, Samson, Fleming, Wooton, and others, shows clearly how much we may hope to accomplish in range improvement in Nevada.

In the course of the coming fiscal year 1915–1916 it is the purpose of the University administration to found in the Nevada Agricultural

Experiment Station and in the College, a Department of Range Management and Range Improvement.

DEPARTMENT OF CHEMISTRY

The Department of Chemistry in the Nevada Station is in a position to be directly helpful to Nevada agriculture. Under Dr. C. A. Jacobson, for several years the major work of this department has been technical researches in the fixation of atmospheric nitrogen by leguminous plants. Studies have been made of the chemistry of plant poisons, and in the present fiscal year a highly technical bulletin was published on Water Hemlock or "Poison Parsnip," giving an account of poisonous quality of the plant and chemical nature of the poison.

It is the duty of the Experiment Station to make its work constructive; that is, to aid in the building of a better agriculture under Nevada conditions. Upon chemical studies of the principal forage plants found in Nevada, we should be able to base in part some important changes in farm and range practice, which will enable us to ship better finished animals. Working in close cooperation and harmony with the future Department of Range Management and with other departments in the School of Agriculture, the Department of Chemistry in the Nevada Station has the opportunity to make its work of distinct public service.

POLICY OF THE STATION

It is the policy of the Nevada Station to found its work upon the actual problems and needs in the agriculture of the State, and to base its allotments to projects and departments upon the standard spoken of in preceding paragraphs—the standard of assistance to an industry. As a branch of the Public Service Division of the University of Nevada, the Station has an opportunity to assist, not only in solving problems and in meeting needs, but in building a more permanent and profitable type of agriculture in the State. Ultimately the work of the Station will find its best justification in the actual effect of its studies upon agricultural conditions in the State. Every project and every experiment should give evidence of a purpose to aid the existing agriculture and to develop a more successful and profitable type.

In the Experiment Station the biological and chemical sciences are at work for the good of the industry. The needs and the problems of the State's agriculture give reasons for the scientific work and show its local advisability and suitability.

When looked at from the point of view of public service, the policy and the field of work of the Experiment Station seems impersonal and almost inevitable—that is, the field of work of the Station is determined by the problems of the State's agriculture; and the projects of the Station must rest upon a sound judgment of problems and of scientific methods for their solution.

The spirit of public service makes it necessary for the whole staff of the Station to recognize the nature of the limitations governing experiment station work and to remember that this work is done primarily for the benefit of the local agriculture. A strong and enthusiastic man trained in the methods of a science and working in the spirit of public service finds in experiment station work an opportunity to apply his knowledge and to use his training and skill. He may be

obliged at times to subordinate his preferences and dislikes, to limit his experimental work severely to fit the actual needs and problems of agriculture. This may become necessary even at a time when the scientific interest attaching to new things discovered may make him ardently anxious to carry his investigation beyond its agricultural relationship and out into the region of discovery in pure science.

The effort to make the Nevada Station of greater service to Nevada agriculture has been consistently supported from the beginning by the Board of Regents, and strongly urged and encouraged by President Hendrick. For several years the Office of Experiment Stations in Washington, D. C., has maintained a kindly and liberal attitude toward several investigations in the Nevada Station whose outlook was primarily scientific, until it has become evident that further work along these lines will contribute more to the special and technical sciences than to agricultural science. The present effort to direct the work of the Station in such a way that it will maintain a high scientific standard and at the same time give vitally needed public service has received their cordial and sympathetic support. At times when the redirection of the work has seemed difficult, the advice and assistance of the Office have been a source of inspiration and encouragement.

As a direct result of the development of experiments and investigations which promise to be useful to the State, the Station itself is gaining steadily in the respect and the support of its agricultural industry.

DEPARTMENT OF VETERINARY SCIENCE AND BACTERIOLOGY

WINFRED B. MACK

EQUINE ANEMIA

This project was undertaken in the autumn of 1907 at the request of numerous horse owners in certain districts in eastern Nevada. During 1906 and 1907 a destructive disease of horses appeared in the districts in question, with which no one was familiar, and caused heavy losses. A study to determine the nature and cause of this disease and to devise means for its prevention or eradication was undertaken. An extensive investigation has been conducted. This work constituted the principal work of the department from 1907 to 1913. During the last two years the project has been less active than formerly, owing to a dearth of material for study. The disease was prevalent during the years 1906, 1907, and 1908, abating considerably during the next year or two, since which time cases of it have been relatively scarce.

The clinical aspects of the disease have been carefully studied and recorded and the pathology, both gross and microscopic, determined. The results of these observations have been published. A considerable amount of data regarding the blood changes which occur in affected animals has been collected, a portion of which has been published. Inoculation experiments have been conducted in an effort to determine whether or not the disease is transmissible, but the results of these experiments have been conflicting and inconclusive. Therapeutic experiments have been carried on in an effort to establish a successful treatment, but without favorable results.

This project has been quiescent during the year from a lack of suitable material. As we are unable to produce the disease experimentally at will, we are dependent upon the occurrence of natural cases for material for study. There is no real progress to record for the year. No further inoculations of horses have been undertaken. The inoculated animals have continued under observation, but have developed nothing significant.

In our last annual report the advisability of continuing this as our major project was discussed. Circumstances do not warrant that course. The economic importance of the disease has lessened as its prevalence has decreased, suitable material for study has been scarce and difficult to obtain, and but little has been accomplished during the past two years. Meantime other important problems have arisen. Consequently other work has occupied the major portion of our time. This does not indicate a lessening of interest in the project, nor is it to be understood as an indication of its abandonment. It is rather an adjustment to altered conditions, and we hope to revive the project during the coming year.

In the conduct of work under this project in the immediate future, we shall continue to undertake to ascertain whether or not the disease is transmissible; if so, the nature of the virus; and endeavor to devise preventive and curative treatment.

CHICKEN CHOLERA

In our preceding report, a project for the study of immunity to chicken cholera by the use of killed cultures of chicken cholera bacilli was discussed; the questions to be answered were presented as follows:

1. Will suspensions of dead chicken cholera bacteria when injected into susceptible birds confer immunity against that disease?
2. What is the duration of that immunity, provided it can be thus produced?
3. Is this a practicable method for the suppression of outbreaks of that disease?
4. Must such preparations, in order to do the work, be prepared from the particular strain of virus which is causing an outbreak, or can stock preparations be used with equally good results?

At the time of that report we had tested the method on but one flock. After about 47.5 per cent of the flock had perished, the remaining 170 birds were injected with killed cultures of chicken cholera bacilli, isolated from the flock. Death loss promptly ceased. The subsequent history of the flock has not been satisfactorily obtained, but reports from the owner soon after treatment was given were favorable.

During the year we have had opportunity to study this disease in two outbreaks in widely separated localities. In the first flock there were 24 birds at the time treatment was begun. A much larger number had died during the preceding month. An examination of a dead bird from the flock for diagnosis yielded a culture of chicken cholera bacilli, which was used to prepare a vaccine for the treatment of the remainder of the birds in the flock. Twenty-four birds were injected with dead bacilli; fourteen days later 22 birds received a second treatment. Two birds had been killed meantime by wildcats. The disease was promptly checked and has not reappeared on that farm. A month after the second treatment these birds were reported to be in good condition.

In the next flock 63 birds were vaccinated, receiving two injections, eight days apart. At the time of the first treatment, 6 individuals were considered absolutely hopeless, and 10 others were so weak and emaciated that their prospects for recovery were considered very remote. During the interval between treatments these birds and 3 others, 19 in all, died. Two weeks later the owner reported that the birds were making a nice recovery and were beginning to lay.

To date we have treated three flocks by the method outlined, promptly suppressing the outbreak in every instance. Our evidence is too limited to be of much value, but it indicates that questions 1 and 3 will ultimately be answered favorably. Experiments to ascertain the duration of the immunity thus conferred are in progress, but are not yet ready for publication.

CONTAGIOUS EPITHELIOMA IN CHICKENS

A project entitled "The Control of Contagious Epithelioma in Chickens by Vaccination" was outlined and approved in December, and work on it promptly undertaken. The opportunity for this study was favorable. The disease was prevalent to such an extent that an abundance of material was readily accessible, so that we were able to conduct a vaccination experiment upon a scale sufficiently large to render the results significant.

Authorities differ regarding the identity of contagious epithelioma and its differentiation from roup and diphtheria in chickens. Some contend that they are but different types of the same disease; others that the conditions mentioned constitute two, and still others, three, distinct diseases. That matter is still in controversy. The malady or type of disease with which we dealt in this experiment manifested itself by dry "scab-like" nodules upon the comb, wattles, and unfeathered cutaneous areas of the head, and by pseudo-diphtheritic (necrotic) membranes upon the mucous surfaces of the head, the eye, mouth, and upper respiratory passages. The disease is destructive, one of the most serious with which the poultryman has to contend. Until recently no control measures were available. Drugs and chemicals have proven universally worthless. Manteufel was the first to immunize birds against it. Hadley and Beach repeated his experiments upon 40 birds, Giltner upon 12, with apparent success. The conditions we met afforded an opportunity to test the method upon a commercial scale. The results demonstrated its success and practicability.

The method employed consists of the preparation of a lymph from the morbid products of the disease for use upon the birds to be treated. The treatment proved successful and satisfactory on the whole, although some trouble due to septic processes was encountered. Seven flocks consisting of 3,878 birds—1,666 of them visibly infected, many of them seriously and extensively, and the remaining 2,212 birds thoroughly exposed—have been treated. In five of the flocks, containing 3,062 birds, the treatment was an unqualified success. In the other two flocks of 816 birds, some trouble followed the injections. It appears as though the treatment in those flocks was detrimental. On the whole, however, the results have been satisfactory. The spread of the disease in the flocks was promptly checked by the vaccinations. The infected birds which were treated ran a shorter and milder course than untreated birds, and the mortality was materially reduced. The results of this work to date have been submitted under date of June 30, 1915, and will be published as Experiment Station Bulletin No. 82. A popular account will be prepared and published as Bulletin No. 84 in the near future.

Work under this project will be continued. We shall endeavor to produce a more refined product for use as a vaccine—one free from objectionable bacteria—and by this means reduce the liability of septic processes resulting from its use; to ascertain the dosage and number of treatments necessary in order to obtain the best results; the duration of immunity; and the practicability of immunization of large flocks in which the disease usually occurs each year before it makes its appearance.

A HEMORRHAGIC DISEASE AMONG CATTLE

During the past six years there have been submitted to this department, for bacteriological examination for anthrax, a considerable number of specimens of blood and tissue, in which the results were negative for anthrax. The greater number of these specimens have come from practicing veterinarians and livestock owners. A few were collected at autopsies performed by the writer. In each instance the clinical appearance and history, together with the post-mortem findings, have led to a suspicion of anthrax. The disease is more or less preva-

lent in the territory from which this material was drawn. Concurrently there have been a number of examinations of similar material from the same territory in which the results were positive for anthrax. In these instances standard cultural and inoculation methods have yielded anthrax bacilli readily. As a consequence the conclusion was reached that we have, in certain districts in western Nevada, a fatal hemorrhagic disease of cattle, which cattle owners and practicing veterinarians are unable to distinguish from anthrax.

The more prominent symptoms are fever, dejection, arched back, staring coat, suspension of rumination, cessation of milk secretion, in practically all cases the passage of bloody urine, and usually of bloody feces. The mortality is high, a few, estimated at from 10 to 15 per cent, recover. Upon autopsy, numerous hemorrhagic lesions are found throughout the subcutaneous and intermuscular tissues and beneath the serous surfaces. There is hemorrhage and edema of the lymph nodes, with sanguinous fluid in varying quantities in the body cavities. In some instances the spleen is enlarged, the pulp dark and softened; in others, there is little or no change in the spleen. There is infarction of the liver in practically all cases autopsied. As a rule, the course of the disease is acute, the animal dying in from four to forty-eight hours after illness becomes apparent.

The diseases with which these symptoms and tissue changes are likely to be associated are anthrax, hemorrhagic septicemia, piroplasmosis, and "corn-stalk disease." As stated above, anthrax occurs simultaneously in some of the herds where this condition has been observed, but our bacteriological examinations have excluded that disease from the consideration of this matter. Piroplasmosis is likewise readily excluded. The *Margaropus annulatus* does not live in this climate. Were it introduced here there would be likely to occur an explosive outbreak of piroplasmosis, terminating abruptly at the approach of winter. No ticks have been found on the cattle which we have examined. The so-called "corn-stalk disease," if its cause lies in the use of corn-stalks as food, is likewise out of the question, as we raise no corn in the localities under consideration. Hemorrhagic septicemia has not been excluded, and it is possible that we are encountering an atypical form of that disease. It is likewise possible that we are encountering a new infection, although that is improbable. It is also possible that we are dealing with an intoxication rather than an infection.

A study of the anatomical changes encountered in this disease, after the exclusion of the anthrax, indicates that it is hemorrhagic septicemia. According to the literature on that disease, the causative organism is readily isolated. However, it is possible that outbreaks may be encountered in which its recognition by bacteriological means will be more difficult than text-books would lead one to believe. We have examined culturally material from a considerable number of cases. In many of these examinations, where the material was strictly fresh, cultures have yielded no growth. In others diplococci and two rod-shaped organisms have appeared with some regularity. There is also an ænerobic rod-shaped organism in much of the material examined. In one case cultures of a bipolar organism were isolated. This is not sufficient, however, for diagnosis when we consider that many similar examinations have failed to yield it.

The information at hand shows the existence of this disease in certain valleys close to the Sierra Nevada Mountains, extending along those mountains for a distance of about 150 miles. As a rule, the losses are scattering, but few cases occurring in a herd. Many herds have lost one or two to eight or ten animals. In one instance about 20 per cent of a herd of 350 animals died during three months last autumn. With the disease so widespread, the situation is serious. It has given rise to much uncertainty in the minds of our cattlemen, and considerable apprehension exists among them. In the aggregate the loss is considerable, and the amount of property at stake is large. Cattle owners and veterinarians have strongly urged an investigation. It should be studied both for its scientific interest and for its economic importance. Consequently on November 2 a project to determine the identity of the disease, and whether or not it is infectious, was outlined and approved, and a systematic study inaugurated. Much work has been done already, but we have not been able to reach a conclusion as to its identity. This will constitute our major project during the coming year.

ANTHRAX

Anthrax was diagnosed in a few localities during the year. The disease, as formerly, has been kept well in hand by the use of commercial vaccines.

It is with sadness that we record the death from anthrax of Dr. T. F. Richardson of Fallon, Nevada. At the time of his death Dr. Richardson was employed by the State as a Deputy Quarantine Officer in the control of an outbreak of anthrax, and contracted the disease while in discharge of his official duties. Dr. Richardson was formerly State Veterinarian of Nevada, and his death removed an earnest and efficient man.

RABIES

The far West was free from rabies until 1909 when it appeared in southern California; since that time it has spread over California and extended into Oregon and Idaho. In April of this year, it appeared in northern Nevada, extending thence from Oregon on the north. During the past three months several cases have come to our attention and a number of people have been bitten by infected dogs and coyotes. Some loss of live stock from rabies has already been reported. Its appearance and spread among coyotes in a large and sparsely populated livestock district promises to become an important and serious livestock problem for the State, as well as a menace to human health. Plans are under way for cooperative work between the United States Bureau of Biological Survey and the state authorities for a campaign of eradication directed against coyotes and other noxious animals.

FATTY DEGENERATION OF THE MUSCLES IN SUCKLING LAMBS

In March our attention was called to an interesting condition occurring in a small band of pure-bred Hampshire sheep. From 150 ewes in the lot about 170 lambs were born. Several lambs, varying in age from three to fifteen days, developed muscular weakness, appearing in the beginning as a peculiarity of gait, soon developing into inability to stand or walk. About 20 died. An examination of several of the affected animals indicated that the trouble was muscular, not paralytic.

Upon autopsy the skeletal muscles generally showed extensive change.

Nearly all of them were pale. Occasionally a small muscle was found normal in color. As a rule, the central portion of each group presented a coarsely granular, glistening appearance, in color more whitish than the remainder, and somewhat resembling fat bacon in color and appearance. Some muscles were entirely involved. Microscopic examination of the affected portions revealed fatty changes.

This condition is briefly discussed by Hutyra & Marek.* They state that the cause is unknown, but suggest hereditary predisposition, too close breeding, excessively high fat-content of the milk. They further state that medicinal treatment is useless, but that the disease is warded off by the introduction of fresh blood in the breeding animals, by exercise and suitable feeding of the mother animals during pregnancy.

The ewes were closely confined in corrals during the winter and fed exclusively on alfalfa. Our suggestion to the owner was that the sheep be given greater freedom and opportunity for exercise with a wider ration (the addition of grain to the diet).

NEW RESEARCH PROJECTS

Two new projects have been outlined and approved, and will be undertaken during the coming year if proper facilities can be provided. The first of these is a study of the value of antianthrax serum in the prompt immunization of domestic animals by the simultaneous use of serum and vaccine, permitting the use of a stronger virus than is possible when virus alone is used; of the therapeutic value of such serum in subacute cases of anthrax; and the cost of production of such serum.

The vaccine method for the production of immunity against anthrax requires about twenty-one days, during which time the natural resistance of the animal is lowered. In herds grazing on heavily infected lands the loss from anthrax during the period of immunization is oftentimes heavy, and undoubtedly may be materially reduced by the method devised by Sobernheim and practiced successfully throughout continental Europe, some South American countries, and Japan. Dawson demonstrated the possibility of the method in Delaware, but it has never come into practise in the United States. Certain commercial houses are offering antianthrax serum for human use, and reports of its use as a therapeutic agent in affected human beings are favorable, but its price is prohibitive for use in animals. The practicability of the method should be demonstrated here and its cost determined. We shall undertake to determine whether the method of Sobernheim is practical in the prompt control of outbreaks of anthrax under Nevada conditions, when the disease appears in herds which cannot be removed from the infected lands; and whether antianthrax serum can be produced and used at a cost which will permit its use on live stock of average value. We shall undertake to produce a quantity of this serum according to standard methods and to test it under field conditions.

The second project to be undertaken during the coming year is the purification and concentration of hog-cholera serum; an attempt to eliminate inert material and contaminating bacteria, and to reduce the dosage. The discovery of hog-cholera serum placed in our hands

*Hutyra & Marek. Special Pathology and Therapeutics of the Diseases of Domestic Animals; authorized American ed., vol. II, p. 815.

an efficient method for the control of hog cholera, but its practical manufacture and use in the field have developed certain difficulties. These consist chiefly in the bulk of material necessary to administer; the presence of a large quantity of inert material; and a high bacterial content even when the serum is prepared under the best conditions obtainable. The administration of such serum frequently causes septic processes, oftentimes serious, sometimes destructive. If the active principle can be precipitated and purified by chemical methods, followed by filtration, in somewhat the same manner as is done commercially with diphtheritic antitoxin, all inert material and bacteria can be eliminated, the dosage can be reduced, and septic troubles eliminated.

We shall produce hog-cholera serum after the Dorset-Niles method. This serum will be tested for potency and used as material for experiment. If by methods of fractional precipitation, followed by dialysis and filtration, the active principle can be separated, the final product will be tested against hog-cholera virus in comparison with the Dorset-Niles serum.

LABORATORY FACILITIES

During the year new offices and laboratories have been fitted up for this department on the first floor of the Hatch Building. This affords much more commodious and better equipped quarters than were possible in our old room, and with the growth of work in the department had become imperative. Considerable new apparatus has been purchased, so that we now have quarters suitable for our work. Upon occupying these rooms, a complete physical separation between this department and the State Hygienic Laboratory, which has been under the direction of the writer since its organization in 1909 and occupied the laboratory jointly with this department, was effected. Plans are being formulated under which I shall resign the directorship of the State Hygienic Laboratory, probably in September, thus effecting a complete separation of these departments. The growth of the work in both departments has rendered this course desirable.

PERSONNEL

Late in December Dr. Edward Records, a graduate of the University of Pennsylvania, an able and experienced bacteriologist, was added to our staff. Dr. Records will devote practically his entire time to research projects.

Dr. Stephen Lockett, also a graduate of the University of Pennsylvania, a veterinarian of wide experience and learning, joined the department January 1. Dr. Lockett is employed as Field Agent in Animal Diseases under Agricultural Extension Division of the College of Agriculture, created by the Smith-Lever Act. While he will devote his time to field work in the demonstrations of methods for the suppression and control of infectious diseases of domesticated animals, his association with this department under the direction of the writer, enables us to keep more closely in touch with conditions throughout the State and to secure material for research which otherwise would not be available. The wisdom of the arrangement by which both extension and research work are under a single direction has already been amply demonstrated.

STATE CONTROL

The provision by the last Legislature for a service to be known as the State Veterinary Control Service to be administered by the Board of Regents of the University in place of the service formerly rendered by the State Veterinarian, later by a State Quarantine Board, brings all veterinary activities in the State under a single management. The writer has been designated by the Board of Regents as Director of the State Veterinary Control Service and ex officio State Quarantine Officer. A State Board of Livestock Commissioners was also created at the last session of the Legislature. The law creating this commission provides for their cooperation with the State Veterinary Control Service in the suppression of infectious diseases. The writer will act as secretary of the board. This brings all veterinary activities of the State, except that of the State Sheep Commission, including teaching, research, extension, diagnosis, quarantine, and control of communicable diseases, under my direction. Suitable arrangements have been made for the proper financing of these various activities. We anticipate the addition to our staff in the early autumn of a laboratory diagnostician by the Sheep and Livestock Commissions. When completed, this arrangement will give us a well-balanced, efficient organization, and the effect of the activities of such an organization will soon be realized in the material reduction of the losses suffered by our livestock industry from preventable diseases. The accomplishment of this organization I have long desired, and I believe that at last we are in a position to meet the needs of the industry in a capable and efficient manner.

PUBLICATIONS

Two papers have been prepared for publication during the year. The first, "Umbilical Necrobacillosis in Lambs," will appear in the August number of the American Veterinary Review. This paper records the occurrence in lambs of a form of infection with the necrosis bacillus which has never been recorded in this country and but twice in Europe. In a band of sheep where 5,200 lambs were born, it was estimated that 1,540 animals from two to ten days of age died from infection with the necrosis bacillus. Extensive tissue changes caused by this organism were found, primarily in the livers, secondarily in the stomach walls, diaphragms, and lungs. A study of a number of lambs led to the conclusion that infection occurred through the umbilical cords at the time of birth. The disease was not found in a number of new-born lambs examined. The latter examinations disproved the opinions of the attendants that the lambs were "born with it."

The organism in question, the necrosis bacillus, is widely distributed and diseased conditions due to it are commonly encountered. Contagious foot rot in sheep; necrotic sore mouth in suckling lambs, pigs, and calves; lip and leg ulceration in sheep, are conditions with which livestock men are familiar. The condition described is very rare.

The second paper, entitled "The Control of Contagious Epithelioma in Chickens by Vaccination," will appear in the near future as Bulletin No. 82 of this Experiment Station. That paper gives an account of somewhat extensive work done during the latter half of the year in an attempt to eradicate from seven flocks of chickens worked with, severe and destructive outbreaks of contagious epithelioma. A vaccine was

prepared from morbid materials collected from the sick birds and used successfully, not only in stopping the further spread of the disease, but in modifying and shortening its course. There were 3,878 birds in the seven flocks—1,666 of them visibly infected when treated, and the remainder of the flocks thoroughly exposed.

The preparation of the lymph used is discussed and the method of use. The results were favorable in five flocks of 3,062 birds. In two flocks of 816 birds some trouble followed the administration of the lymph. On the whole the treatment was successful and satisfactory.

A second bulletin upon the same subject will be prepared in the near future. In this paper we shall attempt to state the subject-matter of the more technical paper in terms readily understood by the poultryman. It will be well illustrated and the disease carefully described.

In conclusion, I desire to express my appreciation for the liberal support and wise counsel accorded during the year.

DEPARTMENT OF AGRONOMY

CHARLES S. KNIGHT

The Department of Agronomy began two projects in April, 1914.

Project No. 1:

The approximate land area in the State of Nevada is 70,285,440 acres. Of this amount about 840,000 acres, or 1.2 per cent, were irrigated in 1914. The State abounds in rich agricultural land, but the lack of additional water for irrigation prevents the cultivation of these large tracts which are now lying idle as waste desert areas. To increase the area of irrigated land it becomes necessary to furnish additional water by means of artesian wells or pumping, or make a more conservative use of the present water supply. This experiment deals chiefly with the latter of these two factors. Many farmers in Nevada are continually applying too much water to their crops for the greatest yields per acre and the best quality of products. It is, therefore, very important to know the proper time of application and the amount of irrigation required for the best results with staple crops. Furthermore, in years of water shortage irrigations should be omitted at those stages of growth when the crop is least affected.

When water is pumped from a considerable depth for the irrigation of farm crops, the expense is very high as compared with the use of surface water. It, therefore, becomes important for the grower to use the least amount of water necessary for the greatest possible profit with the various crops. In this Project No. 1 on the irrigation of farm crops a careful study was made of the different methods of applying water as to the effect on growth, composition, and yield per acre.

Project No. 1 included an irrigation experiment with clover, sugar-beets, potatoes, and wheat. The object of this investigation was to determine the critical stages in the irrigation of each crop and to show at what stages of growth the plants are best able to be deprived of an application of water without causing serious injury to the crops; also to determine the amount of water required for the greatest production, and the production with small applications at the different stages.

With potatoes, sugar-beets, and clover a comparative study was made of the plants at different stages of growth with different methods of irrigation to determine proper stages to irrigate these crops, and the proper amount of water to use at each application for the best results. With wheat the object was to determine at which stage or stages of growth an application of water may be eliminated without greatly affecting the yield of grain, and to determine whether or not two applications of water prove as effective to the yield of grain as three or more applications with the same amount of water used.

Project No. 2:

This project consisted of an investigation of varieties of cereal and forage crops and their improvement. In this experiment row tests

were made of several important varieties of alfalfa, potatoes, stock beets, corn (for ensilage), sorghum (for ensilage), wheat, oats, barley, field peas, beans, millets, and grasses—the object being to determine the varieties of these crops which show special adaptation to the local conditions by their hardiness and yielding capacity, and to improve these varieties by selection. By testing out these varieties in various parts of the State where the altitude and climatic conditions are different, it will be possible to determine the highest-producing varieties of cereals and forage crops for all agricultural districts of the State.

PROJECT NO. 1

An Irrigation Experiment with Clover, Sugar-Beets, Potatoes, and Wheat

The soil on these fields varies from a sandy loam to a clay loam. It has been under continuous cultivation for many years and received a moderate dressing of manure two years previous to the beginning of this experiment. The ground was irrigated early in the fall and plowed about four inches deep. In the spring the ground was plowed again about seven inches deep and thoroughly pulverized by the harrow.

With the beets and potatoes each plat consisted of four rows, the rows being 2 feet apart with beets and 3 feet apart with potatoes. The clover plats were 10 feet wide and the wheat plats 22 feet wide. With the exception of clover all of the plats were 165 feet long, while with this crop the length of plats was 264 feet.

The water applied to each plat was carefully measured by running it through iron pipes two inches in diameter by twenty-four inches long, set level in the bank of the distributing ditch under a four-inch head of water. With sugar-beets the water was applied to each plat through one pipe and required 24.4 minutes for a one-inch application; with potatoes two pipes were used requiring 18.3 minutes; with clover two pipes were used requiring 22.35 minutes for a one-inch irrigation. The head of water was kept constant by having an overflow to other parts of the field or to the drainage ditch.

These iron pipes were made as near the same size as is possible by hand. To prevent any possible error in the rate of flow, a large number of these pipes were calibrated by running water through them for one minute each under a constant head of four inches and then weighing the water. The average was taken for the rate of flow. Practically no variation was found in the rate of flow through the different pipes.

To prevent any appreciable error due to variation in soil a very careful system of checks was used, the frequency of check plats varying with the size of the experimental plats. With wheat, potatoes, and sugar-beets every third plat was a check. Thus by revising the actual yields of the plats in accordance with the check plats, the variation in yield due to the difference in soil was largely removed.

All crops were irrigated by means of furrows. In the wheat, potatoes, and clover the furrows were three feet apart, and in the sugar-beets two feet apart. All of the water applied to a plat remained in the plat. If the water reached the lower end of the plat before the total amount was applied, the water was shut off and the remainder applied the following day. In this way the total application was made as uniformly as possible over the entire plat.

Soil moisture determinations were made at the beginning of the

experiment and at regular intervals during the period of growth before and after irrigation in three locations in each plat at each foot in depth down as far as possible to go with the soil tube, but not deeper than seven feet. The object of these investigations was to determine the effect of the different methods of irrigation on the soil moisture content at different depths.

Since this experiment has been in progress for only one season, the results cannot be used for basing any definite conclusions on the value of the different methods of applying water to these crops.

Clover

The irrigation experiment with clover (Common Red) included 12 plats. The clover was planted in the spring of 1913 with a nurse crop of wheat, and produced one crop of hay that season after the wheat had been harvested. The plats were separated by levees four feet wide and high enough to prevent any overflow of water from one plat to another.

In the irrigation of clover 6-inch, 9-inch, and 12-inch applications were made at the following stages of wilting:

(1) Before plants show need of water by dark-green color of foliage.
(2) When plants show need of water by dark-green color of foliage.
(3) When plants have suffered as indicated by dark-green color of foliage and drooping leaves.

During the season of 1914 two crops of hay were harvested on June 16 and August 5, respectively. Samples of hay from each plat with the two cuttings were selected for a determination of moisture and nitrogen content.[1]

Results—The results show that clover cannot be allowed to reach the wilting stages without materially decreasing the yield of hay; also that on soils of this character applications of from 9 to 12 inches given before the plants show need of water are essential for the heaviest production of hay. However, where the total yield was greatest, the yield per acre-foot of water was low and the quality of hay was inferior to that of other plats, due to the large proportion of coarse stems to leaves. The importance of the time of application of water is well illustrated in the results, since a gradual decrease in yield is noted in the different plats with the same applications of water, as the wilting stage advances, before water is applied.

Clover responded more readily to the heavy applications of water than any of the other crops.

Potatoes

The irrigation experiment with potatoes included 19 plats. The seed was secured from George Peckham, Reno, Nevada. The potatoes were planted on May 14, 1914, in rows three feet apart about 18 inches apart in the row. The potatoes were irrigated by means of comparatively deep furrows three feet apart. Three-inch, six-inch, and nine-inch applications of water were made at the same stages of wilting as noted under sugar-beets.

The crop was harvested on October 1, 1914, and, as with the sugar-beets, the two outside rows of each plant were eliminated. Three hills

[1]The nitrogen content was determined by the official method used by the Bureau of Chemistry, U. S. Department of Agriculture.

in different parts of each plat were selected for a chemical analysis of the starch content.[2]

The results indicated that when plants before receiving an irrigation reach the wilting stage, where they fail to revive at night, it is impossible for them to regain sufficient vigor to produce a satisfactory crop.

In this irrigation experiment with potatoes the highest yields were produced with the smallest, or 3-inch applications of water, although very little difference is shown in yield where the crop received two, four, or five 3-inch applications.

Where the plants were never allowed to wilt the highest starch content was received with the smallest, or 3-inch, applications, but in the three stages of wilting the highest starch content was received with the largest, or 9-inch, applications.

Sugar-Beets

The irrigation experiment with sugar-beets included 19 plats. The seed was secured from the bulk lot of the Nevada Sugar Company at Fallon. The seed was planted on April 27, 1914, with a hand drill, about 1½ inches deep, at the rate of 20 pounds to the acre.

In the irrigation of sugar-beets 2-inch, 4-inch, and 6-inch applications of water were made at the following stages of wilting:

(1) Before plants show a tendency to wilt.
(2) When plants show a tendency to wilt.
(3) When all leaves wilt down once.
(4) When all plants fail to revive at night.

When four leaves appeared on the plants, the beets were thinned to about ten inches apart in the row. The crop received two hoeings, when needed, and was cultivated after each irrigation.

The beets were harvested on October 14, 1914, with an ordinary walking beet-plow. Of the four rows in each plat the two outside rows were eliminated to prevent as far as possible any variation due to lateral diffusion of water from the adjoining plats. After plowing out the beets, they were topped and weighed. Five average-size beets from different parts of each plat were selected, weighed, and reserved for chemical analysis for sugar content and purity.[3]

Results—The results of this experiment indicate that sugar-beets which are not irrigated until they wilt down and fail to revive at night, will produce an unsatisfactory crop; also slight variations in yield with 2- and 4-inch applications, if beets have not wilted to the extent that they fail to revive at night. With the 2-inch applications the beets in all stages of wilting show a higher sugar content than those with great applications. The purity of sugar in beets, however, varies, being greatest in beets which were irrigated only after all plants wilted down once.

Wheat

The irrigation experiment with wheat included 60 plats. The plats were 22 feet wide by 165 feet long and were separated by levees 4 feet wide. Marquis wheat was used. The seed was treated for smut with

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[2]The starch content was determined by means of the Direct Acid Hydrolysis. See Bulletin 107, page 58, Bureau of Chemistry, U. S. Department of Agriculture.

[3]Sugar content and purity determined by means of indirect method. See Bulletin 146, page 14, Bureau of Chemistry, U. S. Department of Agriculture.

a solution of copper sulphate (one pound to 25 gallons of water) and was sown on April 20 with a double-disk drill about two inches deep, using 75 pounds of seed per acre. In the irrigation of the wheat 3-inch, 4½-inch, and 6-inch applications were made at the following stages of growth:

1—Five leaves.	3—Bloom.	5—Dough.
2—Boot.	4—Milk.	

In this test the comparison was made of plats receiving an irrigation at each of the five stages of growth with plats in which an irrigation is omitted at each of the five stages; with plats in which irrigations are omitted at any two of the five stages of growth and with plats that receive the same amounts of water in only two applications, one before and one after heading.

The wheat plats were harvested from August 7 to August 13 with the grain binder. The plats receiving the least total irrigation, when an irrigation at the milk stage was omitted, were the first to reach maturity.

Four feet of grain around the outside of each plat was eliminated to prevent as far as possible any error due to seepage from one plat to another. The wheat was threshed with a small thresher operated by a 6-hp. gasoline engine. This machine made possible the thorough cleaning of the grain and caused practically no grain to be lost in threshing.

General Summary

1—With one irrigation omitted, the omission of the application at the five-leaf stage gave the best results, with a difference in yield of less than 3 per cent in the three highest producers.

2—With two irrigations omitted, satisfactory results were noted only with those plats where irrigations were omitted at the five-leaf and dough stages.

3—Four 6-inch irrigations, with one application omitted at the five-leaf stage, yielded 25.8 per cent more than five 6-inch applications.

4—Omission of irrigations at a stage between the boot and milk stages greatly decreases the yield of grain.

5—Where only two irrigations are possible, 6-inch and 12-inch applications respectively proved most satisfactory.

6—Eighty-three per cent of the results in yield was in favor of the 6-inch applications, the difference being greatest where two irrigations were omitted at the five-leaf and dough stages.

7—The different depths of application showed little effect on the soil moisture where two irrigations were omitted, but when only one irrigation was omitted, an average difference of 12.3 per cent was noted in the first three feet in favor of the 6-inch application.

For the first two feet in depth with 6-inch applications, the average soil moisture content before the irrigation at the milk stage was 20 per cent less where two irrigations were omitted than where only one irrigation was omitted.

Nitrogen Content of Plant

The results of this experiment show a general decrease in the percentage of nitrogen, as the crop advances toward maturity, but no uniform variations in nitrogen content were noted where irrigations were omitted at the different stages of growth, with the exception that in plats which were checked in growth during the early stages the

nitrogen content appears comparatively high, due to the lack of proper formation of starch in plants.

The average nitrogen content for all plats at the different stages of growth is as follows:

Five leaf	4.37%
Boot	2.75%
Bloom	2.09%
Milk	1.40%
Dough	1.25%

PROJECT NO. 2

An Investigation of Varieties of Cereal and Forage Crops, and Their Improvement

Alfalfa

Sixty-six varieties of alfalfa were planted in 1913 by E. A. Howes, former agronomist. Each variety was represented by one row and the rows were 60 feet long and 5 feet apart. The ground was irrigated by means of furrows and cultivated after each irrigation. This test included varieties from Argentina, Australia, Germany, France, Turkey, Spain, Kansas, North Dakota, Washington, Colorado, and Nevada. The seed from the different Nevada types was selected from individual plants of varying conditions of growth. In this experiment no check plats were used to account for variations in soil.

Only one crop of alfalfa was secured from the plats on account of the desire to secure seed from the different varieties. A small section of each row was reserved for the production of seed, but, due chiefly to the heavy growth of forage before irrigation was discontinued, practically no seed was produced from any of the rows. In comparing the yields of the first cutting the variety No. 23753 Australia was the highest yielder with 6,920 pounds of cured hay per acre; No. 27247 North Dakota ranking second with 6,875 pounds per acre; Nevada Nos. 35 and 38 ranking third and fourth with equal yields of 5,855 pounds per acre. In these four high producers the percentage of leaves varied from 34.7 per cent to 36.8 per cent of the entire plant. Considerable variation, however, is found with different varieties in the proportion of leaves to stems.

The variety No. 12694 France with 48.5 per cent of leaves and No. 16,400 Media of Washington with 30 per cent of leaves show the same yield of 3,004 pounds per acre. Although the former variety shows almost 50 per cent of leaves to the plant, the low yield of hay per acre makes it of less value as a hay crop than the high producers recorded above.

No marked variation was noted in the date of maturity of the different varieties.

The seed from the different Nevada types was selected from individual plants of varying conditions of growth, which accounts for the great variation shown in yield per acre of hay. This indicates the importance of selecting alfalfa seed from healthy vigorous growing plants.

Potatoes

In many agricultural districts of the State the potato has become one

of the most important cash crops for the farmer. He has thus shown a great desire to try out any new variety of potato, which shows especial adaptation to his conditions with a view of increasing the profits per acre with this particular crop.

The potato varieties were planted on May 14, 1914, in rows 165 feet long and 3 feet apart, one row to each variety. The following varieties were represented: Peerless, Early Red, Early Ohio, Early Russet, Irish Cobbler, Carmon No. 3, Gold Coin, Rural New Yorker, Burbank, and Great Divide. In this experiment a study was made of the comparative yield and quality of home-grown seed introduced from districts outside of the State.

Of the potato varieties, Great Divide and Burbank were the heaviest yielders, with 13,025 and 10,027 pounds per acre, respectively. These two varieties have been grown for many years in Nevada and indicate the value of well-selected home-grown seed over that introduced from other States. The highest starch content is found in the Early Red, but the yield per acre is only 4,225 pounds. The remaining varieties, however, show only slight variations in the starch content.

Field Beets

In recent years a great many inquiries have been received at the Experiment Station relative to the yielding power and quality of different types of beets grown under Nevada conditions as a supplementary feed for different kinds of live stock. During the past two years sugar-beets have been grown in different valleys of Nevada on a commercial scale as a supplementary feed in fattening cattle, sheep, and swine.

The beet varieties were planted on April 27, 1914. The seed was sown at the rate of 20 pounds to the acre, about one inch deep, in rows 24 inches apart. Here the aim was to compare the value of the sugar-beets, half-sugar beets, and mangels as a supplementary feed in fattening cattle, sheep, and swine.

The results of this test favor the sugar-beet. Although slightly surpassed in yield by the Golden Tankard, a half-sugar beet, the high sugar content gives it a greater value as a food for fattening live stock.

The "Our Ideal" mangel shows a comparatively high yield of 16,616 pounds per acre, but the low sugar content of 4.21 per cent indicates a feed of low quality.

Corn

The dairying industry is being rapidly developed in several agricultural districts of the State. A sentiment has arisen among the dairymen that in order to increase the profits during the winter months it becomes necessary to get away from the one-feed ration of alfalfa hay by supplementing this forage with grain or ensilage. Since ensilage and alfalfa make a good balanced ration and as ensilage provides a succulent and very palatable food when needed, there is a demand for information on the varieties of corn, sorghum, and other forage crops that are best adapted to the local soil and climatic conditions.

The experiment on varieties of corn grown for ensilage included the following: Improved Leaming, Pride of Minnesota, Pride of the North, Sure Crop, Minnesota No. 13, Northwest Dent, Minnesota King, Huron Dent, and Wisconsin Yellow Dent. Each variety was represented by eight rows 300 feet long and 3 feet apart. The seed was planted with

a hand corn-planter 3 feet apart in the row and about 2½ inches deep. Furrows were made between every two rows for the irrigation of the crop.

Although the above hardy northern varieties of corn do not mature grain except in occasional favorite seasons, certain types produce profitable crops of forage, which provides a very palatable and satisfactory food for cattle and sheep when placed in the silo and fed in connection with alfalfa.

On September 9, 1914, a very hard frost occurred which threatened the growth of all varieties. On the following two days the corn was harvested and placed in the silo.

The Improved Leaming, Minnesota King, and Pride of Minnesota were the heaviest producers, ranking in the order named, the highest yield being 19,513 pounds per acre.

The experiment with sorghums grown from ensilage occupied the field directly east of the farm dwelling and included the following varieties: Evergreen Broom-corn, Dwarf Broom-corn, Red Kafir, White Kafir, Dwarf Black-hulled Kafir, Medium Yellow Milo, Feterita, and Shallu. The seed was planted with the hand-planter in rows, three feet apart, and about two inches deep. The crop was irrigated in the same manner as corn.

In the different sorghums used in this experiment, the broom-corns advanced the most toward maturity. Although the growth was checked by the heavy frost early in September, a uniform crop of excellent heavy brush was formed with the two varieties of broom-corn.

The Dwarf Broom-corn made the heaviest growth of 25,535 pounds of forage per acre, but the Red and White Kafirs showed a greater proportion of leaf growth and thus were considered more profitable for forage.

The average yield per acre of the Improved Leaming variety of corn was 16,018 pounds per acre or 23.8 per cent less than that of White Kafir, which produced 21,027 pounds per acre.

Cereals

In the agricultural districts of Nevada, where intensive farming is practised, alfalfa has formerly been the principal crop grown. In recent years the enormous production of alfalfa, together with the gradual decrease in the number of live stock fed in the State, has caused the price of alfalfa hay to drop so low that farmers are gradually replacing portions of their alfalfa fields with other crops, of which the cereals are probably most important. No continuous systematic variety tests have been conducted in this State, and thus there is no available data as to the varieties of crops best adapted to the different localities.

The experiment with varieties of wheat, oats, and barley included 30 varieties of wheat, 36 of oats, and 36 of barley. Each variety was represented by one row 65 feet long. The seed was planted April 20, 1914, about 1½ inches deep in rows one foot apart.

Discussion of Row Varieties of Wheat—In the row test of wheat varieties, Bluestem, White Club, Chul, and New Zealand were the highest producers ranking in the order named, Bluestem wheat from Washington producing 55.3 bushels per acre. The average yield of the

eight check plats of Marquis wheat (Nevada seed) was 36.5 bushels per acre, while the Montana Marquis seed produced 46.8 bushels per acre.

Discussion of Row Varieties of Oats—In the experiment with oat varieties the results show a very low yield for all varieties, due chiefly to the fact that the birds took at least one-half of the grain before it had reached maturity. Of the thirty-six varieties tested, Colorado Kherson, Sparrow Bill, Wisconsin Pedigree No. 1, Great Dakota, Wisconsin Pedigree No. 5, and Wisconsin Swedish Select were the heaviest yielders in the order named, Colorado Kherson producing 44.5 bushels per acre.

Discussion of Row Varieties of Barley—Of the thirty-six varieties of barley, White Moravian (Idaho), Blue Ribbon, No. 682 Heil's Hannah, Boldi, and Chevalier were the greatest producers in the order named, White Moravian being the highest yielder with 69.0 bushels per acre.

The characteristic feature in this test is that the highest producers were two-rowed varieties of barley.

Field Peas

Although alfalfa is the forage crop most generally grown in the State, there is often need for a short-lived legume, where such a crop is desired for one or two years in a rotation. If two years can be devoted to such a crop, common Red Clover cannot be surpassed, but where an annual crop is desired, it is very important for the farmer to know which of these crops is best suited to his conditions, also which variety will produce the greatest yields of good forage or seed.

In the tests of varieties of field peas each variety was represented by one row. The seed was sown May 13, 1914, with the hand drill, about 2½ inches deep in rows 3 feet apart and 65 feet long. This experiment included 16 varieties of field peas.

In the row tests of these 16 varieties of field peas, White Marrowfat shows the greatest yield of 945 pounds of seed per acre.

The California-Mexican Large bean was the only variety planted which produced seed, the yield being 554 pounds per acre. In the plat test of the five common varieties of field peas, the Green Canada produced the heaviest yield of 5,278 pounds of forage per acre.

In the row test with varieties of soja beans, the seed was planted in the same manner as the peas. In 1913 a number of soja-bean varieties were planted and very few bacteria nodules were found on the roots of the plants. As no seed pods were produced, there was a possibility that the lack of the proper bacteria in the soil might be the cause. In the 1914 trial a sack of soja-bean soil was introduced from the Wisconsin Station and applied to one-half of the rows of the soja-bean variety test. The inoculated soil showed no advantage over the soil not inoculated in the growth of soja beans.

The results of this experiment indicate that the local conditions are too severe, relative to late spring and early fall frosts, for the production of soja-bean seed. The indications are, however, that this crop may prove very valuable for forage. The variety of Lucas No. 305 produced 7.939 pounds per acre or 41.1 per cent more forage than the Green Canada field pea under the same soil conditions. Although this crop is coarser in quality of forage than the field pea, the high yield per

acre gives it a place where it should be carefully considered where field peas or other annual legumes are grown as a forage for live stock.

Millets

Millets should become a very useful catch crop in parts of this State where other more intensely cultivated crops fail early in the season, due to some pest or unfavorable soil or climatic conditions.

In the test of varieties of millets the seed was planted May 13, 1914, in rows 290 feet long and 3 feet apart, four rows representing each variety. Seven varieties were included in this test.

The results of this experiment show that the three heaviest producers are Siberian, Golden, and Hog, in the order named, the Siberian millet yielding 6,595 pounds of forage per acre. The Siberian millet matured about one week later than the other varieties.

Cooperative Variety Tests

A variety test of grain was conducted on the farm of L. W. Langford, Stillwater, Nevada, in cooperation with F. B. Headley, Superintendent of the U. S. Experiment Farm at Fallon. This test was conducted on a heavy black loam, free from alkali and quite uniform in texture throughout the plats. The plats were plowed about nine inches deep in March, cross-doubled-disked, but not properly leveled; thus the low and high places resulted in an uneven stand of grain. The soil was in a relatively poor physical condition, being heavily infested with mustard and other weeds, thus resulting in low yields of grain. The plats were irrigated four times by the flooding methods, the first application being made three days after planting, and the subsequent irrigations when the crop showed need of water.

Of the wheat varieties, Little Club, Dicklow, and Bluestem were the highest yielders, in the order named, Little Club producing 31.8 bushels per acre.

Of the oat varieties, Early Mountain, Swedish Select, and Spencer were the greatest producers, in the order named, the highest yield being 24.5 pounds per acre.

DEPARTMENT OF ENTOMOLOGY

S. B. Doten

The principal lines of work carried on in the Department of Entomology in the fiscal year 1914–1915 were as follows:

Studies of Hymenopterous Parasites of the Codling Moth (concluded).

Studies of the "Isle of Wight Disease," or Bee Paralysis; and

Studies of Insect Pests of Alfalfa, principally Cutworms.

Some of the results are here presented in brief.

I. ADAMS FUND PROJECT

Study of Hymenopterous Parasites of the Codling Moth

In the present fiscal year and in the previous one it became increasingly evident that, while further work upon this project might lead to interesting entomological discoveries, there seemed little prospect of its having any direct effect on agriculture.

While the parasitic insects under observation seemed to show interesting changes of habit in attacking a host-caterpillar new to them, still there was little to indicate that they would ever become of any great importance in checking the numbers of the codling moth. These wasplike insects, parasitic on the apple-worm, are themselves attacked to such an extent by other secondary parasites that the increase in their numbers is automatically checked.

Moreover, it became evident that the longevity of the parasitic insects in question, males and females alike, depended largely upon the abundance of a natural supply of sweet food. The presence of plant-lice in the orchard, producing quantities of honeydew, is a condition highly favorable to these parasitic insects. A food supply furnished by the floral nectar of weeds growing in the orchard would be almost equally important—that is, the presence of plant-lice and weeds, both of which are highly injurious to the orchard itself, will furnish conditions favoring the increase of certain parasites of the codling moth, but favoring likewise the increase of their enemies, the secondary parasites. It is apparent that the many complications existing in this matter make it not practical to attempt to check the codling moth by means of its parasitic enemies.

It seemed evident to the writer that this project should be concluded as soon as a definite stage could be reached; for this reason, with the assistance of Mr. George G. Schweis,* experimental studies which had been long in progress were brought to a conclusion. Work on the project had contributed a number of interesting methods of study; certain of the data appear to be of sufficient importance to warrant publication. Such data, however, belong to biological science rather than to agricultural science, and may be published later as contributions to the science of entomology.

Two papers were published in the course of the fiscal year on a method of photographing living insects, which was the outcome of an

*Resigned August, 1915, to enter commercial apiculture.

effort to make photographic records of the activity of hymenopterous parasites under observation. Both papers dealt with a new device for making flashlights of living insects. The titles of these papers are as follows:

A "Cold" Flame for Zoological Work; Camera Craft; San Francisco; October, 1914.

Flashlights of Living Insects; Camera Craft; April, 1915.

Fig. 1—"Cold" Flame from Silver Wire. The wire is vaporized by a Current of Electricity. Courtesy of Camera Craft.

The "cold" flame is produced by switching a heavy current of electricity suddenly through a minute silver wire or a larger wire of magnesium. The wire is fused, vaporized, and, in the case of magnesium, is burned. A momentary flash of extremely intense light is given off from the metallic vapor. The duration of the flash is approximately 1/[illegible] of a second. Through the courtesy of Camera Craft, illustrations are here reproduced, showing interesting phases of insect life. The photomicrographic camera with the "cold"-flame lamp and the switch are also illustrated.

The heavy amperage required, when alternating current 220 V. 60 cycles is used, together with the fact that the flashes are not uniform in size and intensity with alternating current, makes this flash somewhat unsatisfactory under ordinary laboratory conditions. Tests of direct current indicate that where a suitable direct-current supply is available, the flashes are uniform and highly successful.

The work done by the writer in photographing living insects shows that a very great many interesting illustrations of insect life can be made with the ordinary explosive flash powder, which is everywhere available. It is necessary that the flash be produced very close to the

insect photographed where magnified images are required. For this purpose a little hooded metallic lamp with glass front like that shown in the illustration has proven particularly useful.

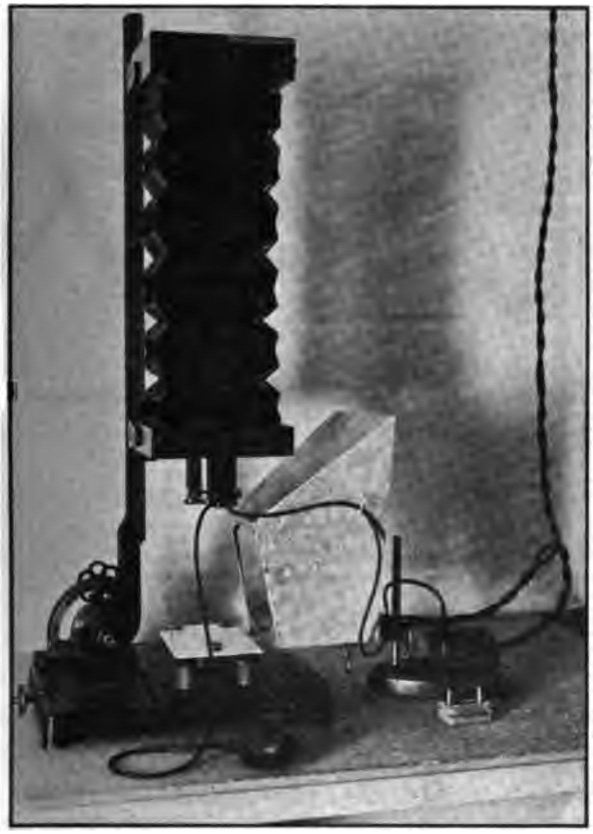

Fig 2—Apparatus for Photographing Living Insects; Camera and "Cold"-Flame Lamp. Courtesy of Camera Craft.

II. CUTWORMS IN ALFALFA

Nearly every summer outbreaks of cutworms destructive to alfalfa are reported to the University. Such injuries occur sometimes in the spring, often in midsummer. Several species of cutworms have been found to cause serious injuries to alfalfa. In fact, since a great many different kinds of cutworms are found in alfalfa fields, it is likely that under favorable conditions almost any one of them may become destructive. Two cutworms which have caused considerable losses in the past in Nevada are the desert cutworm, *Euxoa ridingsiana,* and the variegated cutworm, *Peridroma margaritosa.* The desert cutworm has been found in central and eastern Nevada in the spring feeding in such numbers upon the young shoots of alfalfa that the plant fails to make any growth. It is thus held back for weeks while the cutworms maintain a half-starved existence in the fields.

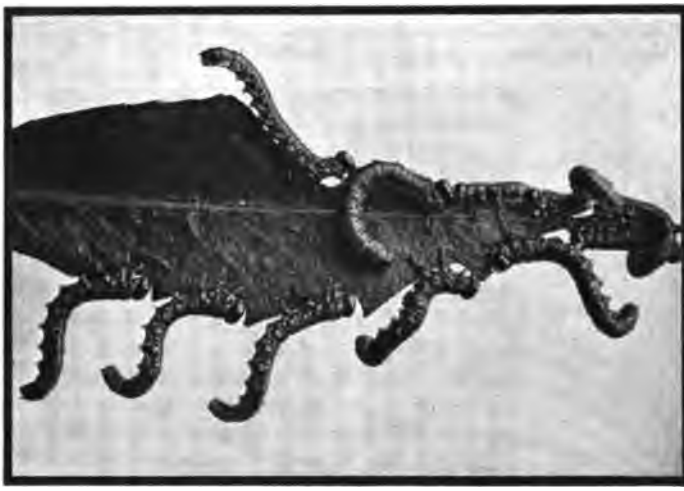

Fig. 3—Saw-Fly Larvæ eating a Willow Leaf (3 diameters).
Courtesy of Camera Craft.

The variegated cutworm has been found in midsummer injuring the second crop of alfalfa in the same way, eating every green leaf as soon as it appears, even eating the buds and nibbling the green rind from the stems; thus checking the growth of the plant for weeks and preventing it from making a start. The illustrations show typical cutworm injuries to alfalfa fields and to individual alfalfa plants.

Drowning Cutworms

The following tests made by Mr. George G. Schweis show how hard it is to drown cutworms:

Two inches of sand in the bottom of a glass jar concealed a cutworm hidden about an inch below the surface. On filling the jar with water, the cutworm came to the top, struggled for two minutes, and then appeared lifeless, floating on the surface and making no further struggle. After five minutes in the water the cutworm was removed and dried, whereupon it recovered immediately and burrowed into dry sand. Ten minutes immersion gave the same result. One worm immersed for an hour and a half recovered when placed in direct sunlight for twenty minutes.

However, in two instances drowning has been used successfully under the following conditions:

In the first place the land was sloping, the furrows comparatively clear of rubbish, the fields swarmed with cutworms which nibbled the green rind of the stems and destroyed every bud before it expanded. Late in the afternoon a heavy head of water was turned down through the furrows, which had dried out hard on the surface. Caught by the water which ran all night, the cutworms were washed down into a ditch where in the morning great masses could be lifted out on a shovel. They were dead and soon decayed. The field immediately made a start and produced an abundant stand of alfalfa, showing the extraordinary hardiness and vitality of this plant.

In another instance, where the check system of irrigation was used, the field was flooded and as the soil absorbed water rather slowly the worms were eventually drowned.

Hogs, Chickens, and Cutworms

Cutworms are eaten by blackbirds and ground squirrels, and are attacked by several parasitic and predaceous insects. Hogs have been used on small patches of alfalfa to very good advantage for the destruction of cutworms: usually the worms did not cover the whole field, but occurred here and there in small areas, not traveling far, but lying about the crowns of the alfalfa under clods and stubble in the daytime, and feeding within a few feet at night. They spread gradually from such patches into the growing alfalfa. Hogs were turned into the cutworm patches, where they rooted around every plant, finding the worms and destroying them. The following notes by Mr. Schweis are an interesting description of this matter:

Fig. 4—Alfalfa Plant-Lice (3 diameters). In the lower half of the figures a maggot is sucking the life out of a plant-louse (Lasiophthicus pyrastri, attacking Macrosiphum creeli). Courtesy of Camera Craft.

> The field where this outbreak occurred contains about 80 acres and the ground actually damaged by the worms covers about 2 acres. The owner of an 80-acre farm across the road had the same trouble over the entire field, but the hogs cleaned them up. It is now impossible to find a single worm on his place, and the alfalfa is growing beautifully. (April, 1915.)
>
> On a ranch about six miles from Fallon, Nevada, the cutworms are cleaned out completely, as the owner turned his hogs into the alfalfa, and the way in which they attacked the cutworms was remarkable. They did not root deeply; but at a depth of from 1½ to 2 inches the field had been completely turned over. The little furrows made by the noses of the hogs around each plant were plainly evident. When asked whether the hogs injured the alfalfa, the owner replied: "You can see for yourself; there isn't a crown injured in the least. The hogs simply nosed around in the sand picking up the worms and paying no attention to the alfalfa." We tried to find cutworms in several spots, but did not find a single one. Across the road where the hogs had not been used, instead of alfalfa 4 or 5 inches high, there was only a mass of dry and brown alfalfa crowns with just the faintest showing of green leaves coming through here and there.

Chickens and turkeys have been used to some extent in the same way. Both are exceedingly fond of cutworms. In the Carson Valley a flock of turkeys destroyed immense numbers of the variegated cutworm (*Peridroma*), and were assisted in this work by flocks of blackbirds. All natural enemies of cutworms are really of great importance, since only small numbers of cutworms are required seriously to retard the growth of an alfalfa field after the first crop is cut or when the crop is just starting in the spring. Under such conditions just a little decrease in the number of worms may let the alfalfa start. As soon as it starts, it gets ahead of the worms and then makes vigorous growth. An alfalfa field when growing may show scarcely any injury from a number of worms which will be quite sufficient to destroy every bud after the crop is cut.

III. BEDBUGS

These insects are often found in bunk-houses on ranches, where they cause a great deal of annoyance. Frequently, the bunk-houses may not be used through the winter, and it has been asked whether under such conditions the insects survive starvation and cold weather. The following tests made by Mr. Schweis in the winter are interesting in this connection:

Thirty-one specimens obtained in a lodging-house on January 21 were placed in tubes in a box and kept under shelter in the open air from January 21 until April 10. At this time only 11 of the 31 were alive and vigorous. The survivors were again placed in tubes in a tin box, packed in cotton, and stored in a refrigerator, whose temperature was maintained constantly between 40° and 50°. They were unpacked July 1, were alive, and to all appearances as vigorous as when placed in cold storage.

A number of extremely tiny bedbugs just hatched from the egg were kept for nearly three months in cold storage without food. All sur-

vived. Eggs kept under the same conditions hatched promptly when the temperature was raised. These experiments seem to show that bedbugs in various stages may survive the winter in bunk-houses, which should be fumigated before they are used again. Owing to the danger connected with the use of potassium cyanide, we have been slow to recommend its use under farm conditions. The results of our experiments in sulphur fumigation seem to indicate that the eggs are not always killed and that two fumigations, a week apart in warm weather, are necessary in order to clean a place completely.

There is danger of loss of life where hydrocyanic acid gas generated from potassium cyanide is used in fumigation, and there is danger of fire from sulphur fumigation. To overcome the latter danger, the following method is used:

A galvanized iron washtub, half-full of water, is set on the floor. A pan containing the sulphur is floated on the water in the tub. The mass of sulphur is worked up into a cone by patting it with the hands. At the top of the heap a little hollow is made with the thumbs, and two

Fig. 5—Bedbugs Feeding on Human Finger (3 diameters). Courtesy of Camera Craft.

or three ounces of alcohol are poured into the hollow. A match touched to the alcohol will ignite the whole mass. The pan will float in the tub while the sulphur is burning; there is little or no danger of fire. It is necessary, of course, to guard in this way against the intense heat produced by the burning sulphur.

In order to make tight a room to be fumigated, every crack is covered with strips of wet paper. All holes are papered and, after fumigation has been started and the door closed, the wet papers are plastered over the cracks around the door from the outside. After fumigation, the windows are opened from the outside and the room is well aired before any one enters it. The wet paper strips are prepared by laying newspapers on the floor, placing a strip of thin board on them and tearing off long strips about four inches wide. Each strip is dragged through the pan of water, is plastered over a crack while still wet and is patted into contact if necessary with the hands. If this work is done rapidly, the wet strips will stay in place long enough to make the sulphur effective.

IV. APICULTURE

Isle of Wight Disease in Bees

More bees should be kept in Nevada, especially in regions where alfalfa seed is grown. More seed will be produced in a field to which bees have access, because the bees fertilize the alfalfa flowers. Nevada honey is of high quality. Comb honey of fancy grade can be produced commanding the highest market prices; the flavor is unexcelled. In comparison with other agricultural industries in Nevada, bee-keeping is relatively unimportant, but it is of sufficient importance to be encouraged. Among the principal causes which in recent years have prevented heavier honey production in Nevada are the American and European foul brood and more recently a new trouble which was noted first in 1914. This disease, bee paralysis or the so-called "Isle of Wight Disease," of bees appeared in several parts of Nevada in May and June, 1914.

It appears to be a disease of the mature bees, rather than of the brood. Its nature and origin have not been completely investigated. Apparently the only remedy is in the breeding of resistant strains of Italian bees.

Upon the appearance of the disease in 1915, Mr. George Schweis began a study of the trouble in cooperation with Dr. Mark F. Boyd, then in charge of the State Hygienic Laboratory. Experiments were made along the following lines:

The attempt was made to determine whether the disease in question is due to unfavorable weather conditions or whether it is caused by bacteria or other micro-organisms. Healthy worker bees isolated in the laboratory were confined in wire cages and fed sterilized honey-water. Nearly all survived through a considerable period and developed no sign of the disease. Diseased bees were crushed in sterile honey-water; the honey-water was then fed to healthy workers from the same hive as those in the first lot. They died with the characteristic symptoms of the disease. Microscopic examinations by Dr. Boyd resulted in the discovery of an organism closely resembling *Nosema apis*, which has been considered the causal organism in the "Isle of Wight Disease."

Sick bees become unable to fly and fall to the ground near the hive or in the fields. The wings are carried almost at right angles to the body. They tremble violently. The abdomen is often distended and trembling, and is usually dragged along the ground as the bee crawls and staggers about near the entrance to the hive. Frequently the hair on the thorax is lacking, so that the bee takes on a dark shiny appearance. The movements are irregular and awkward, and the insects appear as though partly paralyzed.

Notes by Mr. Schweis contain the following description of the disease:

> There were large numbers of peculiar shiny bees staggering about the landing board, and other healthy bees were engaged in dragging the diseased ones from the hives. The bees were taken by their captors and dragged into the clearing several feet from the hive, where they were left to wander helplessly about.
>
> Affected bees do not seem inclined to work and will cluster on the front of the hive in large numbers. Such hives may have all the outward appearance of large healthy colonies, but

> when they are opened practically no bees will be found, although the queen will be on the frame as usual. Frequently, little or no brood or eggs will be found in the hive.
>
> The bees that die all seem to be full of large quantities of honey and excrement; and the abdomen is large and distended. Pressure upon the abdomen may cause a stream of liquid several inches in length to spout from the anal opening. Some bees when returning from the field fall on the ground in front of the hive and they execute many queer movements, running and jumping with wings moving violently. This may go on for several minutes, but eventually the bee will turn on its back and die. At other times diseased bees will emerge from the hive, and after staggering on the landing board for a time will fall to the ground.

In different parts of the West this bee disease has been ascribed to a great variety of causes. In one case it was ascribed to poisoning due to the spraying of apple trees in full bloom. In another instance smelter fumes were thought to be the cause of the disease. In a third instance it was believed to be due to intentional poisoning by enemies. In still another case it was thought to be due to cold wet weather coming suddenly in the midst of a honey flow.

Apparently the weather conditions have some relation to the disease. An outbreak in western Nevada occurred early in June, 1914, after several weeks of unusually warm weather in May. Through May the temperature had reached 80° to 85°, or even 90°, almost daily, going above 95° on several days in the early part of June. A stormy period, lasting for four days with rain, snow, and frost, came on early in June, the highest daily temperature being 60° to 65°. The honey flow was checked and the bees were confined to the hive. Immediately afterward an epidemic of disease swept the colonies and proved exceedingly destructive.

In a number of the Western States, this disease has occurred in very severe form. It is hoped that climatic conditions in Nevada will prove unfavorable to its spread in normal years. An investigation of the disease is being made by the United States Department of Agriculture and it is earnestly hoped that this will lead to the discovery of methods of cure or of prevention.

DEPARTMENT OF CHEMISTRY

C. A. JACOBSON

The work in this department during the past year was carried on along three different lines or projects. The projects under investigation were the same as those reported upon last year, with the exception that certain phases of the projects have been completed and work upon certain others begun. Following is a report of the work by projects:

PROJECT I—THE ALFALFA INVESTIGATION

This project aims at a clearer understanding of the process of nitrogen fixation by leguminous plants, or more specifically by alfalfa, in order that more favorable conditions for the process may be worked out and thereby to increase the food value as well as the fertilizing value of the legume.

In order to gain any insight into the fixation processes, one must first determine the final condition of the nitrogen in the body structure of the plant, and the relation of the nitrogenous compounds to the non-nitrogenous. The work thus far has been confined exclusively to a determination of some of the organic constituents present in the plant, together with the various enzymes present which are the active agents in producing organic transformations in both nitrogenous and non-nitrogenous compounds.

The quantity and character of the chlorophyll in the plant has been determined. Alfalfone and myristone, two ketones of high molecular weight, have been isolated and characterized. The various active enzymes in the leaves, stems, roots, and seeds of the plant have also been determined.

During the past year a nitrogenous compound, present in considerable amount, has been isolated and identified as a saponine. It is a new compound of high molecular weight containing approximately 1 per cent of nitrogen. A full chemical discussion of this substance will shortly appear in a journal article. Two other nitrogenous substances have been isolated from alfalfa, but not enough work has been done upon them as yet to warrant a report.

Besides the isolation of these substances, a thorough investigation was made of the oil in alfalfa seeds. The physical and chemical properties of the oil were determined and the various fatty acids isolated and characterized. Alfalfa-seed oil was found to contain 3.3 per cent oleic acid, 73.2 per cent linolic acid, and 23.5 per cent linolenic acid. Besides these three unsaturated acids, it contains 9.6 per cent of saturated acids composed of carnaubic and daturic acids. The results also seem to indicate the presence of a small amount of behenic acid.

No satisfactory method existed for the separation of the higher fatty acids, and in order to make sure of our conclusions such a method was worked out. This method or rather methods will be published in separate form in some chemical journal.

The future work upon this project should be along the same general lines as that already done. The two nitrogenous compounds, referred to above, should be characterized. Residues obtained from the alcoholic

extraction should be examined further. Extractions of the plant should be made by other solvents, such as water, weak acid solutions, and chloroform. The oils obtained by steam distillation should be investigated. The different parts of the plant, such as the leaves, stems, roots, and seeds, should be examined separately with respect to these nitrogenous constituents. The root tubercles should also be examined with respect to these compounds and to any other form of nitrogen.

The influence of various forms of fertilizers upon the formation of the different nitrogenous bodies in the plant should be studied. Furthermore, work to determine the influence of temperature, moisture, and light upon the fixation processes should be undertaken.

During the year one paper was published upon this project, namely, "Enzymes Present in the Leaves, Stems, and Roots of Alfalfa." The essential results of that work were recorded in last year's report, which was in advance of publication.

The three investigations completed or nearly completed during the present year have not yet been published.

The relation of this problem to agriculture, and particularly to Nevada agriculture, is very intimate and direct. When the nitrogen fixation process is understood, the chances for modifying and controlling the process so as to obtain a larger fixation are favorable, and if the average nitrogen content of alfalfa hay can be increased by only a fraction of 1 per cent, the increased feeding value of this commodity would amount to thousands of dollars per year for this State alone.

PROJECT II—POISONOUS-PLANT INVESTIGATIONS

This project is a chemical study of the toxic principle, whether in one or more definite forms, of the most harmful and poisonous plants of this State. The chemical nature and properties of the poisons are being investigated, but their physiological action, the attempts to obtain suitable antidotes for the poisons, and the best means for the eradication of the plants, are problems outside the field of work in this department, and can, therefore, only receive incidental consideration.

This project had been started by Messrs. Wilson and Dinsmore prior to my coming to the State. I was advised to continue that work, and began by taking up the study of the poisonous principle in water hemlock, locally called poison parsnip.

The resin-like character of the substance, its great instability or marked tendency for polymerization, together with the lack of proper equipment, rendered the work with this substance extremely slow and tedious. A great mass of data regarding the chemical and physiological properties of the substance was accumulated; in fact, nearly all the data regarding the chemical behavior of the poison was procured prior to the last fiscal year.

The work upon this problem during the past fiscal year consisted in verifying certain results, testing out experimentally certain theories regarding the structure of the poisonous principle cicutoxin and collecting and arranging the data obtained, so that definite conclusions could be drawn. A good deal of time was also spent in writing up the material for publication, first in the form of a journal article, and second, a Station Bulletin, covering extraneous material such as historical accounts, botanical and toxicological data.

The chemical investigation of this part of the project is finished,

but some additional information obtained regarding the best methods of eradicating the plant and preventing loss to the stockmen, together with a popular account of the essential results of this work, should be compiled and issued as a farmer's bulletin. This issue should also contain similar treatments, in popular language, of the more common poisonous plants of the State, such as death camas, lupines, larkspurs, loco weed, and ergot.

Of the various poisonous plants found in western America, death camas and lupines appear to be the most dangerous to stockmen, and chemical investigations of the poisonous principles in the plants are now to be undertaken.

One article upon this project was published during the past year, namely: "Cicutoxin, The Poisonous Principle in Water Hemlock (*Cicuta*)," in the Journal of the American Chemical Society, vol. 37, page 916. The paper contains a brief botanical outline showing that our local species is *Cicuta vagans*, Greene, which in all probability is the same as *Cicuta occidentalis*, Greene, with which Chestnut and Wilcox worked in Montana. The article further contains a complete chemical discussion and a brief toxicological account. The former details the method of preparing pure cicutoxin, its physical and chemical properties, its decomposition products, transformations, and chemical combinations, the yield of the poison obtained from the tubers, its molecular weight, empirical formula, and the discovery of a new and characteristic test for the substance. The paper also contains some of the characteristic symptoms of poisoning by water hemlock. The manuscript for the bulletin was ready for publication in April, 1915.

The relation of this project to Nevada agriculture may be shown by mentioning that a herdsman in Austin, Nevada, lost about 500 sheep this spring from poisonous plants, and similar reports have come from sheepmen in Washoe County, as well as some isolated cases from Elko and Clark Counties.

A chemical knowledge and characterization of the poisonous principles in the plants are not sufficient to render the necessary aid and benefit to the stockmen of the State and, therefore, the chemical investigations should be supplemented by physiological and toxicological investigations, as well as by field work with a view to finding suitable antidotes, or the prevention of loss by instruction to the stockmen, regarding the identification of the plants and the time of year they are most apt to cause trouble. The question regarding the best methods, or the feasibility of the eradication of the plants in question, should also be studied by such field men. When this cooperation is secured, the chemical investigations of the poisonous plants would have a direct relation to Nevada agriculture.

PROJECT III—ESSENTIAL OILS IN DESERT PLANTS

The work on wood turpentine, which consisted of an investigation upon the distillate obtained from yellow pine, nut pine, and Jefryii pine, has been completed and an article describing the results was accepted last July for publication in the Journal of Industrial and Engineering Chemistry, and will probably appear in the next issue of that journal. The conclusions as published in the article deduced from this work are as follows: "The presence of practically every constituent of the volatile oil of the oleo resins has been identified in the

wood turpentine of the three varieties of wood under examination. The physical properties and the percentage composition do not always agree, yet they coincide as well as could be reasonably expected, when we consider the inaccuracies of some of the methods available. The results thus far obtained justify the conclusion that the volatile oil obtained from distilling wood under diminished pressure is similar to that obtained from the oleo resin of the same species of tree."

The work has shown that a good quality of turpentine for commercial purposes may be extracted from tops, stumps, slabs, and other waste products of the pine lumber industry. The supply of spirits of gum turpentine is decreasing, because the forests of long-leaf and Cuban pine are being exhausted. As these sources of supply become exhausted and the demand for turpentine increases, the probability of making turpentine from waste wood a commercial success grows more certain. The forest area of Nevada is not great, but the nut pine and yellow pine, two of the most abundant woods, are both rich in turpentine.

The study of essential oils in desert plants has made some progress. Two varieties of sagebrush, *Artemisia cana* and *Ramona stachyoides,* have been found to contain considerable quantities of camphor and, if a cheap method for its extraction could be devised, might be of commercial value. Volatile oils, the nature of which is still undetermined, have been obtained from both *Artemisia tridentala* (common black sage) and *Chrysothamus graviolens* (rabbit brush) in considerable quantities. Experiments have also been carried out upon these plants to determine the season of the year when the essential oil is most abundant. The work has shown that the oil increases in amount during the spring and early summer, reaching a maximum about the middle of August.

Many of the spices, drugs, and perfumes of the present day were first introduced into Europe from Arabia, and many of them were obtained from plants growing in the semiarid regions of southwestern Asia. The plants of desert regions are unusually rich in essential oils, and it is not improbable that native plants growing in the arid parts of Nevada contain valuable ingredients which would be of commercial value, if means for their extraction and purification can be devised.

Dr. Maxwell Adams has been in charge of the investigations under Project III.

SOIL AND WATER ANALYSES

During the year Mr. Silas E. Ross, who was in charge of the commercial work with soils and water, resigned, and his place was taken by Mr. Hugh H. Mosher. The following report is submitted from this department:

Soil Analyses	
Alkali and Sulfates	74
Alkali and Sulfates and Nitrogen	27
Alkali and Sulfates and Nitrogen ($+K_2O$ P_2O_5)	11
Ashes	2
Coals	8
Nitrate Ore	6
Water	
Alkalinity	9
Complete	4
Sanitary	11
Total	152

DEPARTMENT OF METEOROLOGY

J. E. CHURCH, JR.

The Mount Rose Observatory was founded privately by University men in 1905 because of the utter lack of any knowledge of the winter climate of the high mountains along the Pacific Coast, and upon the passage of the Adams Act in 1906 was made a department of the Experiment Station. Since that time three projects have been developed, two of which are approaching conclusion.

PROJECT I—Forecasting Frost from Mountain Tops (Adams Fund)

This project was undertaken to determine whether the low temperatures that regularly occur on mountain tops during storms are followed by a corresponding fall in temperature in the valleys below. On several occasions cold waves on Mount Rose of 3 to 7 degrees F. above zero had been followed from 12 to 36 hours by killing frosts in the valleys. It seemed probable that such phenomena would be found to be a regular occurrence or that their exceptions could be readily forecasted. Apparent success in a similar experiment, but on a far smaller scale, on Mount Royal had meanwhile been announced by Professors McLeod and Barnes of McGill University, Montreal, and the verification of their theory would mean much for Nevada and the mountain States.

In order to obtain a continuous record of the weather on Mount Rose without maintaining an observer there, an instrument was finally perfected by Professor Fergusson, at that time assistant at Blue Hill Observatory, affiliated with Harvard University. This instrument records automatically the humidity, temperature, pressure, wind direction and velocity for a period of six to eight weeks without attention. This is accomplished by a series of pens which trace one above the other their record on a band of paper mounted on a series of drums. The motive power is a long-period lever clock enclosed in one of the drums. A small frame structure nested in the rocks on the summit provides shelter for the observers and a protected place in which to reset the instrument.

Owing to the necessity of making several minor improvements to prevent blizzards from penetrating into the instrument and strengthen the masts and vane against the persistent accumulation of ice fins, it was not until the autumn of 1910 that continuous records could be obtained.

Since that time the instrument has been kept running with but few intermissions, both summer and winter, parties having climbed the mountain on the average of once a month during this period.

Meanwhile base stations of similar character, except that the instruments are reset every week, have been maintained at Truckee and Fallon, on either side of the mountain, to determine the nature of each storm as it approached and passed the summit. The station at Truckee is cared for by Mrs. C. A. Sackett at the nominal charge of $5 per month, while that at Fallon is maintained by the Federal Experiment Farm on the Truckee-Carson Project free of cost.

During the present year, the records of approximately thirty cold waves occurring during the past four years have been analyzed with the following results:

Of these cold waves about one-half were accompanied by nearly synchronous changes at the base stations; one-third were followed within 48 hours by lower minimum temperatures at the base stations; one-sixth were followed by a slight rise of temperature at the base stations. The synchronous changes occur when there is wind at all levels and the air is nearly homogeneous. The one-sixth, in which the temperature on the valley floor rises slightly while the temperature on the summit is falling, are probably mostly due to the presence of clouds or fog below the summit. The one-third, in which a falling temperature on the summit was followed within 48 hours by a lower minimum temperature on the valley floor, represent the clearing of the sky after a storm when the temperature in the valleys is still further lowered by radiation.

It seems probable that many of the cold waves that failed to result in frosts did so because of cloudiness or increased humidity at the close of the storm. This feature of the problem should be further investigated as more pressing problems permit.

The continued maintenance of the observatory on Mount Rose will be inexpensive. On the other hand, being situated above the local disturbances caused by the network of valleys and mountain ranges, it will furnish the only reliable data from which the weather of Nevada and the intermountain region can be studied in its relationship to the general storms crossing the country. It will also provide data of temperature and wind for the study of the distribution and melting of snow on the watershed.

By-Products

Three important by-products have been obtained from this project:

(1) A compact meteorograph, or instrument for recording the various elements of the weather, has been developed for studying mountain meteorology and the climate of forests and cattle ranges. This instrument may come into use at fire-lookout stations in the National Forests.

(2) A considerable amount of data has been accumulated on the action of wind currents in the mountains, and has been made accessible to officials of the Forest Service in perfecting their system of fire protection.

(3) A tracing machine has been constructed which is capable of quickly reducing meteorograph records in various linear scales to a common standard for visual comparison. This is an important consideration where instruments of various types are necessarily employed, for the time formerly spent in copying and comparing records is reduced two-thirds.

PROJECT II—The Relation of Mountains and Forests to the Conservation of Snow (Adams Fund).

This project is the outgrowth of the smaller problem in the Relation of Forests to the Conservation of Snow. On account of the bitter dispute regarding the value of forests for the conservation of

moisture and the control of floods, this department undertook to study that part of the problem that pertained to the conservation of snow, upon which the agriculture of the State largely depends. Since the forests are situated in the mountains and the influence of the two is readily confused, both are included in the project.

It has been necessary to devise not only methods but instruments as the work progressed. A snow sampler and weigher have been perfected, by which the water content of the snow can be quickly determined to a depth of 20 to 25 feet, the greatest depth yet found on the watershed. Although a sampler was devised in France a year before our own was invented, so efficient is the latter that it has been purchased for use in studying the deep snows of the Alps. Evaporation pans also have been perfected for determining the evaporation of the snow on the ground and in the trees; also a snow thermograph for determining the influence of soil and sun temperatures on the melting of snow.

Mount Rose and the basin of Lake Tahoe are ideally situated and forested for these studies. To obtain access to them in all weathers, a sandbag hut was constructed at the elevation of 9,000 feet on Mount Rose and a small motor-boat with tent was used on the Lake until prudence and efficiency necessitated the construction of a cabin cruiser.

The work was begun privately in the spring of 1906 with camera and note-book. In 1908 it became a formal project under the Adams Act, and the meteorologist's entire time for two years was devoted to preliminary studies. During this time forests of various types and at various elevations were visited and courses for the exact measurement of the snow were carefully laid out. Since 1910, owing to the absorption of most of the meteorologist's time in teaching, the studies have been carried on by a local observer at Lake Tahoe and by means of occasional trips from Reno to Mount Rose, except that during 1910–1911 and 1912–1913, the work at Lake Tahoe was practically discontinued. For this reason, the project has progressed slowly, though surely, and is only now entering upon its final stage.

Although some features of the work yet remain to be investigated and a large amount of data must be analyzed, the general conclusion has been reached that forests are a direct protection to the snow, those trees being most effective which allow the snow to reach the ground and yet protect it from the sun and wind. Fir trees have been found much superior to pine as conservers of snow, and forests with glades more satisfactory than continuous forests. Wind-breaks on the lips of canyons and on exposed slopes are indispensable for holding the snow. Because of its hedgelike character, young growth of moderate height seems to be as important for purposes of protection as the taller trees. Since fir grows best on the shaded northern slopes, where the snow is conserved longest, and the pine on the southern sunny slopes, where the snow melts early despite the forest cover, the interests of the lumberman and the irrigationist can be harmonized without great loss to either.

Snow Surveying and Forecasting Stream Flow

One of the early outgrowths of the snow studies is the surveying of the snow cover of watersheds in the spring to determine the amount

of water available for irrigation the following season. In characteristic parts of each watershed definite courses are laid out along which measurements of the water content of the snow are made at intervals of 25 to 100 feet, according to the irregularity of the snow and the length of the course. Because of the uneven precipitation that occurs in the Tahoe watershed and adjoining portions of the Truckee basin, twenty major courses have been laid out, varying in elevation from 6,225 to 10,800 feet. These courses can be surveyed by two persons in two weeks.

The method of making estimates based upon the snow survey is shown in the following bulletin issued the present season to the users of water in the Tahoe-Truckee basin, and to property owners around the Lake:

Seasonal Snow Survey of Lake Tahoe Basin and Estimate of the Maximum Rise of the Lake, Spring of 1915

Method I. Based on High-Level Measurements and "Percentage Relationship" to the Season of 1914.

West Side of Lake Tahoe	*1914 In. Water Content*	*1915 In. Water Content*	*Percentage of 1914*
1. Ward Creek (7,000 feet elevation)	52.8	40.9	77.5
2. Blackwood Creek (6,950 feet elevation)	37.8	25.7	68.0
3. Rubicon Range (8,100 feet elevation)	63.1	35.7	56.6
4. Mt. Tallac (8,200–9,750 feet elevation)	44.9	30.2	67.3
Gilmore Lake (8,200 feet elevation)	65.9	35.6*	54.0
Lake Lucile (8,200 feet elevation)		37.7	......
Glen Alpine (6,800 feet elevation)	26.6	15.8	59.8
Average percentage of 1914 for west side			63.9
East Side of Lake Tahoe			
5. Mount Rose (9,000 feet elevation)	48.1	25.1	52.1
Summit of Mount Rose (9,000–10,500 feet elevation)	32.7	21.0	64.2
6. Marlette Lake (8,000 feet elevation)		20.0	......
7. Spooner's Ranch (7,000 feet elevation)		8.8	......
Average percentage for east side			58.2
Average percentage for entire basin			61.1

*But snow was rapidly melting.

Based upon measurements on Rubicon Range, the present season (1915) is 96 per cent of 1910 or 86 per cent of *normal.*

Actual rise in level of Lake Tahoe of 1914 (including water discharged during spring)	5.15 feet
Estimated rise in level of Lake Tahoe 1915 (on basis of 60.9 per cent of 1914)	3.15 feet
Minimum level (January 13, 1915)	6,226.90 feet
Estimated maximum level (subtracting .25 feet drawn off, but adding .2 feet from storm May 1–12)	6,230.00 feet
Height of dam	6,230.00 feet
Present height of Lake (May 12)	6,228.25 feet
Estimated additional rise in the Lake	1.75 feet

Method II. Based on the Land Area and the Water Content of the Snow Cover, April 1.

	Area	*Water Content*
Below 7,000 ft., Area 122.6 sq. mi.	West side...74.6 sq. mi.	15.3 in.
	East side...48.0 sq. mi.	4.8 in.
Above 7,000 ft., Area 168.3 sq. mi.	West side...87.2 sq. mi.	33.8 in.
	East side...81.1 sq. mi.	18.7 in.
Average water content		18.2 in.

Total land area, 290.9 square miles.
Area of Lake surface, 192.7 square miles.
192.7 : 290.9 : : 18.2 : estimated rise of Lake.
Estimated rise of Lake, 27.5 inches, or 2.29 feet.
Lake level (April 1), 6,227.70 feet.
Estimated maximum height (without reference to loss of snow by evaporation and seepage), 6,229.99 feet.

However, the precipitation of May 1–12 should offset evaporation while the Lake is filling up. The Lake, therefore, should be practically level full the present season as it was during the season of 1914.

TRUCKEE BASIN, 1915

Summit Station (above Truckee	Snow, 86.4 in.	Water, 40.0 in.
Marlette Lake	Snow, 49.4 in.	Water, 20.0 in.
White and Galena Creeks	64 per cent of 1914 and 112 per cent of 1910, or normal.	

The rise of the Lake-level was several tenths of a foot below the estimate made, although the seasonal estimate has usually been accurate within two-tenths of a foot.

It has since been found by a study of Lake-level data, tabulated by Mr. H. F. Alciatore, Meteorologist of the U. S. Weather Bureau, that the run-off during abnormal years, such as 1913–1914, does not afford a safe standard of comparison. A reestimate made by taking 86 per cent, the relation of the season to normal as based on measurements made on Rubicon Range, and 2.98 feet, the normal annual rise of Lake Tahoe, gave a corrected rise of 2.56 feet and a maximum level of 6,229.46, which was within three-tenths of a foot of the maximum actually attained. Further refinements since made have given still closer results.

The usual snow-scale method of measurement, in which a few graduated stakes are set up on each watershed to show the depth of the snow, is extremely inaccurate, not only because the stakes give no clue to the water content of the snow, but also because in wind-swept mountainous regions they afford little evidence even regarding the average depth of the snow. The variations in the following measurements made consecutively every hundred feet on Mount Rose will illustrate:

15,3 inches, 47.8, 71.5, 113.0, 45.0, 19.5, 19.0, 88.6, 29.3, 35.9, 88.6, 70.6, 31.2, 89.6, 14.2, 55.8, 98.6, 112.5, 57.0, 80.5, 119.3, 94.2, 88.7, 26.6, 25.6, 13.1, 24.6, 50.2, 48.2, 72.2, 85.5, 42.6, 42.0, 66.6, 43.0, 86.5, 34.1, 7.0, 16.6, 24.1, 106.1, 100.4, 67.3, 54.5, 19.5, 8.2, 71.8, 73.8, 27.0, 35.7, 80.0; average depth, 56.4 inches.

Of these measurements only a few are near the average depth of the entire course. And while readings on stakes at these few chance points would have been of value on that year, in another year with different wind conditions, readings on the same stakes might readily have been worthless. The average water content of the snow over the entire course was 22.2 inches; the relative density was 39.4 per cent.

During the coming year, accumulated data in the snow studies will be prepared for publication, and studies of the evaporation of snow and the forecasting of stream flow will be carried so far as possible toward conclusion.

The study of the evaporation of snow has special importance in furnishing the means of estimating one of the chief losses on the watershed. For this reason, even the fragmentary data so far obtained have been sought by the Geological Survey in making a preliminary study of the Walker River Basin with a view to the establishment of a recla-

mation project there. Evaporation data are particularly needful where the water content of the snow cover is estimated in acre-feet rather than in its percentage relationship to a previous season's snow cover and run-off.

By-Products

The chief by-product of this project is a small tubular snow and soil thermograph or recording thermometer, which can easily be inserted down a sampler hole to any desired point in the snow or soil. This instrument has a period of seven days and is especially valuable in determining the possibility of premature run-off, due to unfrozen ground, and the relation of freezing temperatures to the destruction of soil bacteria, particularly the eel-worm.

PROJECT III—The Temperature Survey and Relation of Topography to the Occurrence of Frost (State and Private Funds).

In 1911, under state appropriation a temperature survey of the agricultural lands of the State was begun to determine the intensity and duration of frost with a view to finding more satisfactory sites for orchards and the amount of orchard heating that must be done to save a crop. So pessimistic had the Nevada rancher become regarding the possibility of saving his fruit that little effort was put forth to protect it.

This survey is being made by means of a series of fifteen recording thermometers and two sets of maximum and minimum thermometers placed at suitable points from the highest land under irrigation ditches to the lowest lands of the valley. Thus far the survey has been confined to the Truckee River Basin and the Truckee-Carson Project. The instruments are cared for and the record sheets changed mostly by volunteer observers. At the end of four years the stations are moved to a new location, except that a central station is maintained in each district to correlate the temperature there with that at the University. In connection with the survey, semiofficial experiments in orchard heating have been made by the meteorologist to determine the feasibility of protecting fruit against frost.

The results obtained early in the survey were published in Bulletin No. 79 of the Nevada Agricultural Experiment Station,"The Avoidance and Prevention of Frost in the Fruit Belts of Nevada," which has found an unexpectedly wide demand in this country and abroad. Later data confirm earlier conclusions that, with elevation above the valley floor, there is a decrease both in the number of frosts and in the number of hours of orchard heating required, the decrease in the number of frosts with increase in elevation of 250 feet in the Truckee Meadows having been found to be from fourteen to five and in duration of freezing temperatures from at least forty hours to sixteen. Also, except in abnormal years or in the coldest places, an average of two heatings each season will save the fruit. Moreover, it seems probable that at 28°F. or higher, except when the fruit is setting, no heating will be necessary to assure a moderate crop. The selection of late-blooming trees of good quality, some of which have been found already acclimated during the survey, should make it comparatively easy for the Nevada rancher to establish at least a home orchard that would require but little protection.

A simple rule has been devised for forecasting the probable maximum intensity of frost, namely, to subtract from the maximum temperature of the day on which the forecast is made the fall in temperature that normally occurs during the night when the weather is clear. In the spring at Reno this fall in temperature is 30–32°F. Therefore, with a maximum temperature of 65°F., the minimum temperature should not be lower than 33°F.

A method apparently similar has since been proposed by Professor J. Warren Smith, Agricultural Meteorologist of the U. S. Weather Bureau.

Moisture in the air, particularly in the form of clouds and wind, will greatly decrease the fall of temperature. On the other hand, unusual dryness will increase it considerably. For this reason the fall of temperature at night in the autumn is much greater than in spring, and to make a satisfactory forecast 44–46°F. should be subtracted from the maximum temperature of the day.

The accuracy of frost forecasts can be readily increased by making a series of observations on the relative influence of clouds of various densities and winds of various velocities in checking frost. Only once in recent years in the Truckee Meadows and probably in western Nevada has frost occurred during the prevalence of wind.

The present season, after consultation with the horticulturist, a study of the effect of local situation on the development and destruction of blossoms was begun. A few orchards were selected where stations of the temperature survey were maintained. The blossoms were carefully graded into five classes according to their degree of unfolding, and the development of the blossoms was carefully noted each week.

The frost with wind referred to above occurred May 3 and by its widespread damage afforded an opportunity to study the relative hardiness of blossoms. The temperature near Reno was 26°F., and where the orchards were protected from the wind by hillsides or other screens, the amount of injury was far less than where the exposure was complete. Blossoms that were small to medium in size generally escaped, but the more developed blossoms, except the peach, which is hardy, were to a large extent destroyed. A peach tree that had lost as high as six-sevenths of its blossoms bore two-thirds of a crop and the fruit was little, if any, inferior to normal fruit.

Near Steamboat and at Verdi the temperature fell to 18°, and even the small blossoms of all kinds were completely destroyed. At Lewers's Ranch, the temperature fell to 22°F., but the later fruit was still in small blossom and escaped. Near Sparks, one orchard of late trees came into bloom just after the frost and was consequently unaffected by it.

The varieties of fruit that passed through this frost with least damage were:

Snare's Ranch: (Temperature, 26°F.)

Pewaukee, ⅜ crop; Winesap, ¾; Northern Spy, ¾; Ben Davis, ⅜; Walbridge, ¾ to full; Delicious, ⅓ to ½.

Crawford Peach, ⅔.

Red Egg Plum, ¾; Green Gage, ¾.

Sour Cherries, approximately ⅔.

Mason's Residence, Reno:

Large Red Peach (in full bloom at time of storm), ½ to ⅜ crop.

Lewers's Orchard, Franktown: (Temperature, 22°F.)
All stone fruits and early apples and pears were destroyed.
Late apples came to maturity as follows:
Apples in full crop: Little Lady, York Imperial, Seek-No-Farther, Buckingham, Wine Apple, Wagoner, Pilot, and Golden Pippin.
Apples bearing ⅔ crop: Newton Pippin, Rome Beauty, Summer Sweeting, and Smith Cider.
Apples bearing ½ crop: Jonathan, Gloria Mundi, Van der Veer.

Although one-fifth to one-half of the blossoms of two pear trees survived, the fruit was dwarfed. One of the hardiest of the apples that was unaffected by the frost is the Pilot. These apples are large, have very little core, and are good keepers. The trees grow to a large size and bear well. However, they mature slowly, taking from 15 to 20 years to reach their bearing stage.

If the frost had occurred two weeks later, the destruction of the fruit would have been much greater. However, the intensity of frost in western Nevada is so slightly below what the fruit can endure, that only minor adjustments in the selection of sites for orchards and fruit to plant in them are necessary to restore confidence in at least the home orchard.

The further study of the relation of topography to the occurrence of frost and its effect on fruit should be made the main project of the department and, if possible, be financed from the Hatch Fund. To this project should be added the development of a simple system of frost forecasting for the isolated farmer, so that frost need not come upon him unawares.

During the coming year, four of the temperature stations now in the Truckee Meadows will be placed at Pyramid Lake, Lahontan, The Island, and Stillwater to complete the temperature survey of the Truckee-Carson Project. Because of the influence of large bodies of water in moderating the temperature, it seems probable that very favorable locations for horticulture may be found near Pyramid Lake.

The temperature survey will be concluded in the Truckee-Carson basins before publication on this unit is made. The general plan is to map the basins into zones according to the intensity of the frost and the hours of heating required, to study the progress of temperature changes with a view to local forecasting, and to compare the thermal intensity of the growing season on slopes with that in valley bottoms.

Publications:

1. "The Value of High-Level Meteorological Data in Forecasting Changes in Temperature"—S. P. Fergusson, Station Bulletin. In press.

This bulletin presents the results of experiments conducted on Pike's Peak, Mount Royal, Blue Hill, and at Mount Rose. Of approximately thirty cold waves at the latter place, five-sixths are felt both on the mountain and in the valley, but only one-third of these occur sufficiently early on the mountain to give adequate warning below.

2. "Snow Survey Provides Basis for Close Forecast of Watershed's Yield: Rapid Economical Methods of Measuring Large Areas of Snow at High Altitudes Prove Useful at Lake Tahoe, Nevada" —J. E. Church, Jr., Engineering Record, April 17, 1915.

This article outlines methods of snow surveying and sets forth the

advantage both in accuracy and in economy of field measurements of snow over measurements at a single station, or even group of stations.

The expense of the survey of the Tahoe Basin was considerably less than one-half the amount necessary to maintain the eight snowfall stations there. "It is, of course, true that these stations furnish climatic statistics of precipitation, measured storm by storm, and of snow on the ground, measured month by month, which the snow survey, if restricted to the time of melting, cannot do."

3. "Motor Boating 6,200 Feet Above Sea-Level: A Defoe Cruiser, Built for Cruising in Winter"—Arthur L. Smith—Motor Boating, March 15, 1915.

Describes the construction of the "Mount Rose," a home-built cabin cruiser, and its value for snow studies and winter cruising on Lake Tahoe.

4. "Horticulture in Nevada"—J. E. Church, Jr.—Standard Cyclopedia of Horticulture, vol. IV, in press.

This article sets forth in a general way the topography and climate of Nevada, the relative importance of its agricultural industries, and, in detail, the nature, problems, and possibilities of its horticulture.

Cooperation.

The year has been one of large and practical cooperation. Data on the precipitation and evaporation of snow were placed at the service of the Geological Survey in making a report on the feasibility of establishing a federal reclamation project on Walker River.

In return for the seasonal snow survey of the Tahoe Basin, the Reclamation Service has given this department the use of land and adequate buildings for headquarters at the outlet of the Lake and is sharing in the maintenance of the snow observer.

Close cooperation is being planned by the Nevada Section of the U. S. Weather Bureau with a view to assisting in the extension and completion of the snow studies inaugurated by this department and to the ultimate adoption in all of the watersheds of the State of the methods of snow surveying thus developed.

Officials of the Forest Service also have consulted with the Department in formulating plans for the study and charting of air currents in the National Forests with the view to improving present methods of fire protection; they have also made inquiries regarding the meteorograph on Mount Rose with the view to obtaining a similar instrument to record the climate in the more inaccessible parts of the forests.

Finally, the Experiment Farm of the Bureau of Plant Industry at Fallon has extended its cooperation by taking charge of four additional temperature stations placed at Pyramid Lake, Lahontan, The Island, and Stillwater, which, with the Mount Rose base station at Fallon and a temperature station maintained by the U. S. Weather Bureau at Fernley, should furnish an accurate record of the climate of the Truckee-Carson Project.

THE VALUE OF A DEPARTMENT OF METEOROLOGY

A Department of Meteorology in Nevada has particular value along the following lines:

1. To perfect methods of determining the amount of water available on the various watersheds for irrigation each season.

Most of the water used for irrigation in Nevada falls in the form of snow on the high mountains, and its amount varies with elevation and situation. Only 5 per cent is stored in reservoirs. Experiments already made by the Station have demonstrated that close forecasts of run-off can be made sufficiently early to permit the adjustment of crops to available water.

The department's methods are now being adopted by the U. S. Weather Bureau in Nevada. Cooperation is being arranged with the purpose of ultimately applying such a forecast service to all parts of the State.

2. To study Nevada climate with reference to agriculture.

A mountain State like Nevada has a complex climate as compared with the States of the plains. This is especially true in regard to temperature. In 1915 the orchards of Fallon and Glenbrook, sixty miles apart and having a difference of 2,500 feet in elevation, blossomed fully two months apart. The fruit at Fallon was injured by an untimely freeze; because of its lateness, that at Glenbrook escaped.

The study of the climate of Nevada should be directed along the following lines:

(1) The climatic survey of basins and slopes to determine the relative intensity of the growing season of each both day and night; the frequency, intensity, and length of frosts with a view to the economical protection of gardens and orchards; the relative humidity and the effect of wind with reference to the winter-killing of fruit trees and alfalfa; the progress of temperature changes on bottom lands and slopes to facilitate the forecasting of frost; and, finally, the comparison of the climatic elements found here with those found in other States to facilitate the introduction of congenial plants.

The most pressing need is the development of the home orchard by selecting frost-resistant and late-blooming plants and trees, and learning how to protect them easily and economically. The survey being conducted in the Truckee-Carson Basins indicates that on the average not more than two heatings will be required each season to save a full crop and that, except when the fruit is setting, no heating will be required to save a crop sufficiently large for home and local consumption. So valuable is this latter observation, if true, that its accuracy should be thoroughly verified.

Local experiments of this ntaure are too detailed to be conducted by the U. S. Weather Bureau, and the instruments employed by their voluntary observers are not adapted to the work.

(2) In cooperation with the Departments of Biology and Agronomy, attention should be given to the relation of climatic factors to plant-growth, not only the climate of the air, but the temperature of the soil, especially as affected by irrigation. Such studies might be valuable in experiments now in progress on the Experiment Station Farm, especially the effect of winter temperatures on the control of the eel-worm.

(3) In similar cooperation with the Department of Animal Husbandry, studies could be made of the effect of outdoor wintering on the milk production of dairy herds, particularly the effect of rain, snow, mud, winds, etc.

(4) It may be possible to increase our present limited knowledge of the climate of the stock range, particularly the temperature, pre-

cipitation both of rain and snow, and relative humidity, for their possible bearing on its improvement.

Through the efforts of Professor Fergusson, Associate Meteorologist, who is an experienced designer and maker of meteorological instruments, the department is well equipped to conduct the studies outlined. and can furnish further apparatus at a nominal cost. The advantage is of utmost importance, for instruments adapted to the work are both difficult to obtain and are expensive. Furthermore, Professor Fergusson is a trained meteorologist, having resigned as first assistant at Blue Hill Observatory, Harvard University, to have a share in the pioneer work here.

3. To teach agricultural students and others the value of instruments and the meaning of climate, particularly the relation of local weather to general storm movements.

4. To advance the general science of meteorology:

(a) Along agricultural lines of more remote interest than the preceding, as (1) the nature of frost phenomena, and (2) the study of mountain winds in their relation to the spread of forest and brush fires.

(b) Along pure lines, as the study of the climate of the Great Basin and upper-air phenomena as affected by the topography of the Great Plateau, and in assisting in procuring data for world meteorology.

5. Finally, as at present constituted, the department is particularly fitted to design and repair instruments for other departments of the University.

These are the reasons why we urge the establishing of the Department of Meteorology on a permanent footing in the Experiment Station and University. Dean Knight strongly favors giving instruction in Meteorology in the College of Agriculture. The College of Engineering has made use of the department in designing and testing instruments.

For the immediate future, the continuance of the Department is imperative, for the data on the Relation of Mountains and Forests to the Conservation of Snow are yet to be prepared for final conclusions and publication, and the records being obtained in the temperature survey of the Truckee-Carson Basins must be tabulated and analyzed.

When the larger projects now under way are concluded, as they should be by the summer of 1917, and possibly sooner, the department can probably be maintained for $2,500 per annum, providing $500 can be apportioned from the College of Agriculture for instruction in meteorology, and $300 by the University for designing and repairing instruments in the colleges of the University. If necessary, Professor Fergusson can earn one-fourth to one-third of his salary by devoting a proportionate amount of time to outside work. However, the work that should normally fall to the department would occupy his entire time.

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AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Annual Report of the Board of Control for the Fiscal Year Ending June 30, 1916

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NEVADA AGRICULTURAL EXPERIMENT STATION

REPORT OF THE DIRECTOR

THE SCIENCES ASSIST AGRICULTURE

The American system of experiment stations was founded to give the assistance of the natural sciences to the agricultural industry. In the course of the last century, as a group of sciences—chemistry, bacterology, entomology, plant pathology, and others—grew from earlier beginnings into usefulness and importance; it became increasingly evident that these sciences were often able to give unexpected explanations of agricultural practices sometimes centuries old. The sciences thus began to show why farm practices were desirable or undesirable, and more and more they became able to point the way to progress in agriculture.

The sciences themselves were built up largely by means of tests and trials and experiments. The whole subject of chemistry, for example, grew rapidly out of long series of experiments and tests made for a purpose, and grouped together in investigations of the nature of substances. When chemistry was applied to agriculture early experiments taught vitally important facts in the relation of the chemical constituents of the soil to plant growth. The earliest studies in bacteriology began to show in agriculture the relation of bacteria and other minute organisms to disease in plant and animals. These sciences themselves like all the modern natural sciences were based upon experiments; the experimental methods belonging to the sciences gave us a new and extraordinarily helpful means for investigating many of the problems of the agricultural industry.

Toward the close of the last century, therefore, the Federal Government founded in each of the States an experiment station whose purpose it is to make careful, accurate, scientific investigations of the problems of agriculture. The stations have proven their worth as institutions for giving scientific assistance to the agricultural industry to the degree in which they have solved problems and have steadily aided in the development of a better agriculture.

As a whole, the work of the stations in America has been signally successful and of great importance. Diseases of plants and animals have been studied; means for cure or eradication have frequently been worked out; insect pests of field, garden, and orchard have been investigated until their whole life history in relation to the crop has been made clear and remedies have been found. In soils, in feeds and feeding, in plant breeding, plant diseases, in the introduction of new crops or new strains of old ones, in all these fields and many more the stations have found it possible to give substantial aid to the agricultural industry.

Recently especial efforts have been made to carry to the farmers themselves the facts and methods discovered by the stations. The most substantial and enduring work is done in the classrooms of the agricultural colleges, where the facts and principles discovered by the stations form a large part of the college course. Still, the numbers actually reached in this way are so small that special organizations have been created under state and federal funds to bring to the

people the great mass of information discovered in the experiment stations.

Throughout America each agricultural college now has its special corps of workers in agricultural extension. Their presence in the field is giving new effectiveness to the work of the stations by bringing them into closer touch with the farming communities and thus into contact with problems which need investigation. In all the States the problems are many and vital. In every agricultural region there is an unlimited opportunity to make the natural sciences serviceable to the agricultural industry.

Year by year the stations are thus bringing the sciences into new respect among the people and are gaining for scientific investigation in general a widespread confidence and support. The stations have shown that scientific work and thought are not things apart from the practical everyday world; but that microscope and test tube and library can make vitally important contributions to the earliest, and most fundamental, of all industries.

The sciences which have had this direct contact with agriculture have gained immensely in the extent of their field work and knowledge, in power and in reality. Every science grows steadily in influence and in self-respect as it grows in usefulness.

PLANS AND PROJECTS

First of all, then, in each State the experiment station seeks the problems of agriculture. The agricultural problem is stated as clearly as possible and a plan is made for its solution. This plan is called a project; funds are set aside for its support. In the study of any problem in agriculture we may use the methods of one or of several sciences. As an example, in the rapidly developing dairy industry of Nevada, we have the silage problem. It may be stated as follows: What type of forage can best be grown under Nevada conditions for the production of ensilage; and in what type of silo can it most profitably be stored?

It is foolish to make a campaign of good advice with the slogan, "Build a silo!" unless we know what ought to be put into the silo. Corn? Will corn ripen sufficiently where the nights are cold and the growing season is short? Alfalfa? Will it not be more profitable to make hay of alfalfa? What forage plant shall we grow for silage? A few plots of land on which suitable crops may be tested, a few experimental silos, some feeding tests, many chemical analyses of various crops cut at different stages, by these means the station should be able to answer the group of questions which make up the silage problem in Nevada. The methods of the sciences of agronomy, animal husbandry, and chemistry, all will contribute to the answer. If we make this silage problem a project of the Nevada Station, the project will thus require the close cooperation of a group of well-trained men working together for a common purpose.

A NEW DEPARTMENT IN THE STATION—THE DEPARTMENT OF RANGE MANAGEMENT

Several new projects were outlined in the course of the present fiscal year; the principal ones are those connected with a group of important problems in range conditions in Nevada. For the study of these range

problems a new department was founded in college and station under the title, Department of Range Management. The work in this department has been organized along the following lines:

Methods of preventing losses due to poisonous plants;
Reestablishment of native range forage plants;
Relative importance of native range forage plants;
Carrying capacity of the range;
Introduction of foreign range forage plants;
Restoration of white sage ranges.

The Department of Range Management was founded only after very careful study of the lines of work through which the Nevada Experiment Station can best serve the State. The projects in the new department were planned after consultation with the Division of Grazing, United States Forest Service at Washington, D. C., and each project was submitted to the Office of Experiment Stations for advice. These projects received the hearty approval of the office, and the Forest Service has promised all possible assistance to the success of the work. There is no other problem in Nevada agriculture more pressing or more important than the problem of the condition of our sheep and cattle ranges. Cattle and sheep and their products are increasing steadily in value; meanwhile the available range forage is steadily falling off in condition, because of continued overstocking and bad range management.

At the outset of this work, however, it should be stated that it seems almost useless to discuss methods for improving the open, uncontrolled range. Close competition among sheepmen or cattlemen on the open range is resulting here, just as everywhere, in overstocking, ruinous methods of grazing, and the gradual disappearance of the forage. No sowing of seed, no methods of management, are applicable under such conditions. The station must find for the present its field of work on range which has passed into private ownership and control. Many owners of live stock in Nevada now express a conviction that all the range lands on the public domain, not suitable for farming, should immediately be placed by the Federal Government in grazing reserves administered along the lines laid down by the Grazing Division of the United States Forest Service.

When the University of Nevada decided to found its new Department of Range Management, a very earnest effort was made to obtain a man whose special training and experience would fit him preeminently for this work. Finally the choice fell upon Mr. C. E. Fleming of the United States Forest Service, whose qualifications for the position are indicated by the following account of his training and experience.

Born in Utah in the year 1889, Mr. Fleming grew up in close touch with the sheep and cattle industries. His father, Mr. A. M. Fleming, of Logan, Utah, was an owner of both sheep and cattle; and Mr. C. E. Fleming saw range conditions from the saddle as a boy and learned to know range forage in connection with the sheep and cattle business. A graduate of the cow-camp and the sheep-camp, schools which teach realities, Mr. Fleming graduated later from other agricultural courses, first at Logan, Utah, 1909; later at Cornell University, 1910.

After leaving Cornell, Mr. Fleming entered the United States Forest

Service as Plant Ecologist; later he became Grazing Examiner, and in this capacity he rode range in Oregon, Montana, Idaho, New Mexico, Arizona, Utah, Wyoming, and Colorado. In 1915, he was put in charge of the Jornada Grazing Reserve in New Mexico, a tract of 216,000 acres of depleted range land on which experiments in range management are in progress under the United States Forest Service in cooperation with New Mexico stockmen. Mr. Fleming came directly to the University of Nevada from the midst of his work on the Jornada Reserve.

Irrigation Experiments, Project 1, Hatch Fund, 1914–1919; Project Leader, Dean C. S. Knight, assisted by Mr. J. B. Menardi.

In Nevada we have far more land than we have water to make the land useful. Our primary question here is not how much can we get from an acre of land, but what can we get from an inch of water. Nevada agriculture is directly dependent upon irrigation for its existence. This does not mean that dry-farming is impossible; it is apt, however, to be exceedingly dry farming. There are favored spots here and there in the State where dry-farm methods are useful and where crops are raised without any form of irrigation. In the main, Nevada agriculture is limited strictly to the supply of water available for irrigation. The water which we now have in our streams, without storage, and without the development of further supplies, can be made to go very much farther in crop production if less of it is wasted and wiser use is made of all of it.

In this project Dean Knight aims to find out at what stages of the growth of the plant the water does the most good and is most necessary, and to find out how much water should be applied in each irrigation and how many irrigations are needed. The plants under trial include wheat, potatoes, alfalfa, and sugar-beets, the most important crops of the State. As fast as results are obtained from this project the work will be extended to other types of soil and to other parts of Nevada for test and trial under local conditions.

Such studies of the use of water in irrigation: how much to apply, how often, and at what stages of plant growth, point the way directly to a wiser use of water in irrigation and to a far more extensive and profitable type of farming in Nevada. They are of special use to the man with a limited water supply, to the man who is farming on a small scale. There is every reason to believe that if the water now used in irrigation throughout Nevada were all used to the best advantage, it could be made to irrigate nearly twice as much land as the area now under cultivation. It is easy to see what this would mean to the State. Irrigation studies, therefore, form one of the most important fields for experimental work in the Nevada Station. Such projects are based directly upon the hardest problem of Nevada agriculture, the water problem, which is always with us and which always will be.

Variety Testing and Crop Improvement, Project 2, Hatch Fund, 1914–........; Project Leader, Dean C. S. Knight, assisted by Mr. J. B. Menardi.

What is the best strain of wheat to grow under irrigation in Nevada? What is the best wheat for dry-farming? Of oats? Of potatoes, alfalfa, sweet corn? Is there a field-pea for Nevada? How will sudan

grass do here; will it seed? What variety of corn should be grown for ensilage? Will a mixture of field-peas and oats make good ensilage? Can we do anything with sorghums in Nevada? Will feterita grow in Elko County? Can we grow sugar-beets without irrigation in Washoe County?

What do you think of Grimm alfalfa for Nevada? Peruvian alfalfa? Can we not select a still better strain of alfalfa for Nevada? Can we improve Marquis wheat and make it maintain its best quality year after year? Is sweet clover useful under Nevada conditions?

The problems of best varieties of the best crops, problems of possible new crops, problems of how to make the best ones still better—just such questions as these coming to us from the people of the State are the foundation underlying this project. The work has been in progress for many years and it has yielded important information to be taught in the classroom and carried out by extension workers to

Figure 1—A Test of Varieties of Sorghum for Ensilage. Experiment Station Farm.

the State. This project, like the first one, is undertaken primarily in the interest of the man who has limited land and water and capital and must make all of them go just as far as possible in the production of the best crops.

Anthrax Serum, Project 3, Hatch Fund, 1914-........; Project Leader, Dr. W. B. Mack, assisted by Dr. Edward Records.

Losses from anthrax continue among Nevada cattle. This disease is deadly to all classes of live stock and it is usually fatal when it attacks human beings. With the increasing value of live stock, losses from disease become more expensive every year. Where a few years ago on western sheep and cattle ranges the loss of a few head hardly led to comment, such a loss now leads to active measures to put an end to the disease and to prevent its recurrence.

The vaccine treatment of Pasteur has been used successfully under Nevada conditions; but it is open to the objection that it takes about three weeks to make the animals immune to anthrax by this method. Meanwhile, their natural resistance is lowered, and if they are still grazing on infected lands, they may die of anthrax before they have been made immune. Heavy losses thus occur and to this degree the Pasteur vaccine method seems somewhat unsatisfactory.

Instead then of using vaccines which consist of weakened strains of the actual bacteria which cause anthrax, it may be possible to employ an antianthrax serum consisting of the clear portion of the blood of animals, which have been made highly immune to anthrax.

In Europe, in South America, and in other countries closely connected in a commercial and scientific way with Europe, antianthrax serum has been used since the end of the last century in the prevention

Figure 2—Sudan Grass Under Experiment at the Station Farm.

and the treatment of anthrax. In America, even for use with human beings infected with this deadly disorder, there has been up to the last few years no supply of serum.

The conditions under which cattle are raised in Europe are of course very different from conditions on western ranges, but Dr. W. B. Mack concluded some years ago that it might well be possible to prepare and use an antianthrax serum economically and successfully under our conditions. Suitable quarters and an ample supply of experimental animals were provided and in the course of the fiscal year, 1915-1916, the preparation of such a serum has been attempted in the Department of Veterinary Science and Bacteriology with every prospect of success. Any improvements in methods of controlling anthrax will be of direct benefit to the rapidly growing dairy industry in Nevada.

Chicken Cholera, Project 4, Hatch Fund, 1914-1916; Project Leader, Dr. W. B. Mack, assisted by Dr. Edward Records.

In recent years fowl-cholera has assumed considerable importance in Nevada. This disease is not very common in the United States as a whole, for which reason perhaps few studies of methods of control have been made. The usual advice given is to quarantine sick birds promptly and to disinfect the premises. This is always good general advice, but with this disease under the conditions of poultry raising in Nevada such measures appear to be utterly insufficient to put a stop to outbreaks.

Pasteur showed that it might be possible to make fowls immune by using vaccines consisting of greatly weakened virus. Still, his method has apparently not been followed successfully in America; and it appears to be thoroughly well worth while to attempt the preparation of some form of vaccine for use in this disease under our conditions.

Apparently, the most promising method is that of killing the active living virus and then injecting it into the tissues of the birds to be treated. Careful experiments along this line are expected to show whether such dead cultures of bacteria will make chickens immune to fowl-cholera, and to show how long they can be expected to remain immune, and whether in general the method will be of use in suppressing this disease in large flocks in which it has appeared.

Of course, Dr. Mack's real object in undertaking this project is to give assistance to the industry of chicken raising, which is growing more important every year in western Nevada. Roup and chicken cholera check the growth of the chicken industry, and form a disease problem which the farmer has no means of solving. Here the aid of the modern science of bacteriology gives direct assistance to the industry; the Experiment Station finds its legitimate field of work in such studies. If the station discovers means of controlling chicken diseases in Nevada, it will give the most direct aid to the poultrymen, not only in this State, but in other parts of the country where problems of the same kind are found.

Insects Injurious to Alfalfa, Project 5, Hatch Fund, Active in 1916-1917 and thereafter; Project Leader, S. B. Doten.

From time to time in past years the station has studied methods of controlling outbreaks of insects injurious to various crops in Nevada. Among them have been the western cricket, grasshoppers, plant-lice, and several varieties of cutworms.

The annual crop of alfalfa hay is by far the most important crop in Nevada. Naturally anything which injures the hay is a direct injury to the whole livestock industry, which is as important an industry in Nevada as fruit raising in California or corn growing in Iowa. As the ranges are eaten out more and more every year, the hay crop becomes continually more important, for the livestock industry rests directly on two things—the range forage and the hay.

With the increased value of live stock and their products, and the increase in the cost of hay for winter feeding, insect injuries to alfalfa become more and more important. In addition to definite studies of the insect pests of alfalfa now found in the State, to be financed from the Hatch fund under this project, a careful study of the alfalfa

weevil should be made under state funds; the State should provide funds to send an entomologist to Utah to go over the weevil situation there and then publish a well-illustrated pamphlet for distribution to Nevada farmers showing the work of the weevil, telling of methods of control now used in Utah, and illustrating the structure and habits of this insect. This will give warning before the appearance of the alfalfa weevil in Nevada, and may enable us to check at once the earliest outbreaks which appear.

The station will examine free of charge all alfalfa insects which are sent to the University, and will investigate any outbreak of such insects which may be reported.

Poisonous Range Plants, Project 6, Hatch Fund, 1916-........; Project Leader, C. E. Fleming.

No stockman in Nevada will question the importance of this project and the good reasons for spending a considerable share of the federal funds upon it. Losses from poisonous plants seem, if anything, to be on the increase in Nevada; with the increased value of sheep and cattle and their products these losses make a staggering total. It is regrettably common to learn of the loss of hundreds of sheep from a single band from some form of plant poisoning.

The purpose of this project is to find out what plants are causing such losses in Nevada, to determine the habits of these plants, where they grow, how they spread, the time of year when they are poisonous, what kinds of live stock are poisoned by them. We plan to find out likewise how to prevent animals from being poisoned. Perhaps it may be possible to uproot and destroy small patches of the most deadly plants; again it may be possible to destroy them by cutting off the tops until the roots die, or by grazing them closely with animals not injured; or warning signs may be put up to keep herders from driving sheep upon areas where poison plants are growing.

As fast as such information is gained, we plan to issue bulletins showing how each plant looks, and telling where it grows and under what conditions it is poisonous. This information will make it possible for stockmen to be on the lookout for poisonous plants and to keep sheep and cattle away from them. With some such plants it may even be a good plan to fence parts of the range where they are growing.

The fact of the matter seems to be that losses from poisonous plants are increasing wherever the range has been heavily overstocked; and there is everything to indicate that the poison-plant problem will grow more important every year. The station plans, therefore, to make this line of work substantial and to finance it heavily. We would like to have farmers and stockmen notify us promptly whenever poisoning of live stock occurs. Specimens of plants thought to be poisonous should be pulled or dug, roots, stems, flowers, and all, and then pressed dry between newspapers, packed between boards, and sent to the University by parcel post or express for free examination.

Native Range Forage Plants, Project 7, Hatch Fund, 1916-........; Project Leader, C. E. Fleming.

As soon as the station began its studies of methods of range improvement, it began to be noised about in the State that the University was going to reseed the open range with wonderful plants which would

grow far more readily than the native plants, and which would soon restore the ranges to the best possible grazing condition.

The University would certainly like to do this if it could, but science is not performing miracles. The Nevada ranges are rapidly getting into the condition of a middle-aged man, who has lived recklessly and has wasted all his powers of mind and body in his earlier years. Such men often go to physicians expecting a medical treatment which will restore promptly constitutions wrecked by wrong ways of living.

However, the case of the Nevada ranges is rather more hopeful than this, because the ranges, depleted as they are by overstocking, still have the power to restore themselves under proper treatment. The problem here is how to restore the native range forage plants which made the ranges valuable in the beginning. Range is just like any other pasture. If you overstock any hillside pasture of large extent and containing a wide variety of plant-life, the plants which are good to eat will be the first to disappear. There is always a struggle among plants to occupy the same ground. When the palatable and nutritious ones are gone, the bitter or thorny or woody kinds come in and occupy the ground. In time, grazing animals may destroy almost all that is good in the pasture, which will then grow up in coarse brush and thorny, bitter, or poisonous weeds.

The whole purpose of this project is to study the habits of the valuable native forage plants and to work out methods of handling live stock which will permit the plants to grow and and to reseed themselves. There is probably no more important line of work which the station could undertake.

Very much of this information will have to be gained in cooperation with men who have been in the livestock business in Nevada for years. It is perfectly fair to say, however, to any one who expects to see the open range benefited by these studies that there is little or no hope of any improvement whatever on open public lands, and that there is everything to indicate that the open grazing country in Nevada will continue to grow worse instead of better. The range country must come under administrative control and authority before right methods of handling live stock on the range can be introduced.

Relative Importance of Native Range Forage Plants, Project 8, Hatch Fund, 1916-........; Project Leader, C. E. Fleming.

Before we can decide which plants we should try to reestablish on Nevada ranges, we must know clearly which plants are the best ones. Almost every piece of range differs from other ranges near it. The weeds and brush and grasses which grow in the valleys are different from those on the hills; the plant-life of the hills is very different from that of the higher mountains. The plants of central and southern Nevada are different from those of the northern part of the State. To work out completely methods of encouraging the best plants on all these various types of range will require years of study in close cooperation between the University and the stockmen of the State.

Introduction of Foreign Range Forage Plants, Project 9, Hatch Fund, 1916-........; Project Leader, C. E. Fleming.

From time to time in the course of the last fifteen years a great many experiments have been made both by experiment stations and

the United States Forest Service in the introduction of foreign range forage plants. On the whole, the outcome of this work has been distinctly discouraging. Few of the introduced species have survived and of the survivors exceedingly few have proven better than the native forms of plant-life. However, there is always the possibility that in regions whose climate is similar to that of western America, forage plants and grasses may be found which will prove exceedingly useful on our western ranges. It is the purpose of this experiment to test the most promising species in cooperation with the United States Forest Service and with the Office of Seed and Plant Introduction of the United States Department of Agriculture.

Carrying Capacity of the Range, Project 10, Hatch Fund, 1916–........; Project Leader, C. E. Fleming.

This project is, of course, very closely related to the two which we have just discussed. Any given section of range can safely support only a limited number of animals. Just as soon as it is crowded, the feed begins to fall off and fewer animals can be carried every year. On the other hand, where the range is managed rightly and is grazed in such a way that the native forage is encouraged and assisted in spreading, the carrying capacity of the range increases; and from year to year a few more animals can be carried. There is nothing else in the whole agriculture of the State more important than to stop injuries to sheep and cattle ranges in Nevada and, on the whole, to increase their carrying capacity. Little or nothing has been done for the open ranges of the public domain. A great deal can be done for ranges which are under control. The United States Forest Service has made a splendid beginning in this work in Nevada, but the most important grazing problems are the problems of the lands devoid of forest growth.

Relative Feeding Values of Crops of Alfalfa, Project 11, Hatch Fund, 1915–........; Project Leader, Dr. C. A. Jacobson.

For many years it has been maintained that there is a distinct difference in feeding values between the first and second crops of Nevada alfalfa hay. It is the purpose of this project to show whether there is any important chemical difference in the two crops which will account for the apparent difference in feeding values. The first crop grows through a long cool spring and early summer. The second crop comes on rapidly in the full heat of midsummer. Is there a difference in feeding value corresponding to the different conditions under which the two crops grow. Will cows fed first-crop alfalfa give more milk and better milk than those fed second-crop alfalfa? Why? It is the purpose of this project to tell why; that is, if a real difference is found.

The work will be conducted in cooperation with dairymen feeding the two crops. And careful feeding tests under controlled conditions may be made later by the Department of Dairy Husbandry of the University of Nevada.

ADAMS FUND PROJECTS

In 1906 the success of the station work, which had been carried on in all the States under the Hatch fund for many years, led to increased federal appropriations under the Adams Act. It was understood

that work done under the Adams fund should be more technical in character and should go deeper into agricultural problems than that which has been conducted under the Hatch fund. This was no criticism of the Hatch fund work, for the creation of the new fund was good evidence of the success of the work done under the old one. It was felt that if astonishingly beneficial results could be gained by scientific studies of agricultural problems, then deeper and more thorough investigations should in the long run prove yet more beneficial. At the present time both funds are used almost alike for thorough studies of agricultural problems; but the Adams fund is restricted to work of a more technical and difficult character.

Timber and Snow Studies and Snow Surveying, Project 12, Adams Fund, 1908-1916; Project Leader, Dr. J. E. Church, assisted by Professor S. P. Fergusson, and Mr. Arthur Smith of Tahoe City.

Two lines of work with different purposes are here included in a single project. It is the purpose of the snow studies to observe and to measure the degree to which forest timber retards the melting of snow in the Sierra Nevada Mountains. The purpose of the work in snow surveying has been to devise a method of measuring the amount of snow which accumulates in the mountains during the winter, as a basis for estimates for the amount of water which will be available in summer for irrigation and hydro-electric power.

I. *Timber and Snow:*

This project was planned to get answers to the following questions:

(1) What protective influence upon the melting of snow is exerted by the forests of the Sierra Nevada?

(2) How do these forests retard the melting of snow?

(3) If the timber were to be cut off suddenly over a large part of the watershed of a stream, would the snow then melt so rapidly as to cause floods in the lowlands, followed by extremely low water later in the season?

(4) Or is it probable that as fast as the timber was removed, brush and second growth would spring up and protect the snow?

(5) Again, if the forest about the head of a stream were all suddenly cut away, is it perhaps true that even then the wind would sweep the snow into great drifts in hollows and canyons and back of the hills where it would melt as slowly as in a forest?

It is perfectly clear to any one who knows mountain country and irrigation in western America that the higher mountains are reservoirs of snow. High in the mountains the snow melts slowly and feeds the streams below. Irrigated agriculture along such streams is often directly dependent for its existence upon the snow of the mountains. The agricultural question involved in the study of timber and snow is this: How will changes in forest conditions in the mountains affect farming in the valleys? What steps can be taken to prevent injuries to stream flow? How may the forests be utilized as sources of lumber and still be used to protect the irrigation water which is stored as snow?

Such questions are not to be answered in one year, nor completely in ten years. Persistent and extraordinary efforts have been made by Doctor Church to work out methods of observation, to devise accurate

apparatus for snow measurement, to establish stations in the forests, and in general to provide the equipment necessary in work of so difficult a character. All this has required years of work and very heavy expenditures. Dr. Church's studies of the protection given by forests to snow have been unique in many particulars. In fact, in thoroughness and in originality of method these studies stand high in both America and Europe.

In 1906, when this project was being planned, the question of the degree of protection given by forests to snow was still a matter of great prominence in American thought. In fact, the whole popular movement for the creation of our national system of forest reserves had been based largely upon the assumed importance of this relationship. It was freely stated then and later that the cutting down of our western forests would result in floods, in the drying up of springs and streams, and in the inevitable ruin of regions dependent upon water storage in snow for irrigation.

On the other hand, the most exact information upon the relation of forests to snow in the Tahoe region would not, of course, solve the whole great conservation problem, nor answer the question for all forested regions. The degree to which mountains and forests in general retard the melting of snow will depend upon the kind of forest, the character of the ground covered, the ruggedness and steepness of the mountains themselves, their nearness to the coast, their height above sea-level, how far north they lie, and other factors.

The Tahoe region in Nevada and California, however, offers an almost ideal opportunity for such studies; for the lake never freezes and its hundred miles of shores are open to boats throughout the winter. Still, it should always be kept in mind that the protective influence of timber upon snow is not so much an agricultural problem as a problem in forestry whose importance must be determined by foresters. That is, while in the administration of the national forests this relation must be considered to some extent, it will usually be considered separately for each national forest or group of forests in connection with plans of forest management, simply because conditions in the various forests differ so widely.

The Tahoe basin is nearly all included in the great Tahoe National Forest created by President Roosevelt in 1906. It contains so little merchantable timber that its removal could scarcely have a serious effect on stream-flow and water-storage. And, on the whole, since practically all of the watershed region of the Sierra Nevada is now included in forest reserves under the administrative control of the United States Forest Service, it is clear that general studies of forest and snow relationships in those mountains have become somewhat remote from the field of work of the Nevada Experiment Station.

Still, very largely because of Dr. Church's infectious enthusiasm for this line of work, and because of the originality of his plans and methods, these studies of the protection given by forest timber to snow continued to be loyally supported in the Nevada Station until from the great mass of observations and measurements some conclusions could be drawn. Three years ago, however, a preliminary analysis of the records showed that this project was naturally approaching a con-

clusion, and that the necessary field-work was nearly complete. Meanwhile, however, other interesting possibilities had shown themselves.

In these snow studies apparatus of an original character had been devised for rapid and accurate measurements of the depth and the water-content of snow as it lies in great banks under the forest trees or on the hillsides during the period of melting. It now appeared that in the semiarid regions, where rainfall is unimportant, from measurements of snow in the mountains made early in the spring, just before the beginning of the melting period, unusually accurate estimates can be made of the amount of water which will be available in summer for water-power development and irrigation. In the Tahoe basin it became apparent that if measurements were made each spring over well-chosen courses running from the lake shore high into the surrounding mountains, then by comparing these measurements with those of the previous year or with the average of several years, it was possible to foretell with much accuracy the level to which the lake might be expected to rise in summer. This highly important result of the timber and snow studies will be discussed below under the title, "Methods of Snow Surveying."

In the coming year, 1916–1917, the studies of the protection given by timber to snow in the Sierra will be concluded and terminated. They will ultimately be published as a contribution from the University of Nevada to forest meteorology in western America.

II. *Methods of Snow Surveying:*

Lake Tahoe is used by the United States Reclamation Service and by The Truckee River General Electric Company as a storage reservoir. The lake itself has an area of 192 square miles; the total area of the Tahoe basin is 519 square miles. Below Tahoe, in the canyon of the Truckee River, there are a number of power plants which develop a great quantity of electric power. Further down in the valleys about Reno and Fallon, Nevada, the Truckee is used to the utmost in the irrigation of productive and important farming districts. Power and irrigation are alike dependent upon storage in Lake Tahoe, one of the largest reservoirs in the west.

The level to which the lake rises during the melting of the snow is controlled by means of gates at the outlet, the head of the Truckee River. By means of these gates the lake level may be caused to vary between readings of 6,224 and 6,229.8 feet. Along the shores of the lake there are roads and meadows, camps, summer homes, and resorts, all of which would be damaged by too great a rise in the lake. In years of high water, in the spring during the melting of the snow, the gateman at the outlet must decide how much water can safely be held. In warm spring weather, the snow melts rapidly and the water pours down the mountain slopes into the streams and so to the lake. Under such conditions, if too much water is held during the slower melting of early spring, the lake may rise too high, and damage to lake shore property may result. The water storage problem at Tahoe is the problem of saving water in years of plenty for years of scarcity. After a winter of heavy snowfall it is important to hold back all the water, that may safely be held, during the whole period of the melting of the snow.

The questions involved are the following:

(1) At the beginning of the melting period each year, how much snow is there in the mountains around the lake?

(2) If all the water which reaches the lake were to be held by the dam, how high would the lake then rise by midsummer?

(3) How much water can safely be held back by the dam before the most rapid melting sets in?

(4) If the spring is late and cold, and the snow melts slowly, will all the water from the snow reach the lake?

(5) If the hot weather comes early and lasts long, how much water will it then be safe to hold?

Of the questions involved in water storage at Tahoe, the first one given above is the most important—*How much snow is there in the mountains?* There are several ways in which this question may be answered with more or less accuracy. We can base an estimate of the amount of snow in the mountains upon measurements of the amount which fell during the winter at a few well-chosen points along the lake shore. The measurements are made by caretakers at the various Tahoe resorts, by reading snow stakes set up in the suitable places. (H. F. Alciatore, United States Weather Bureau, Reno, Nevada.) Another way in which to estimate how much snow there is in the mountains is to measure the height to which the snowfall in winter raises the level of the lake. As it falls into the lake, it melts and the lake rises. From the amount of such rise one can tell how much snow has fallen into the lake itself, and thus get an idea of how much has fallen in the mountains around the lake. (L. O. Murphy, Hydrographer, Reno Power, Light and Water Company, Reno, Nevada.) Still another way of telling how much snow there is in the mountains is to send out men equipped with suitable apparatus to measure the snow in the spring just before it begins to melt. (Dr. J. E. Church, Jr., University of Nevada, Reno, Nevada.)

For several years past, estimates have been made by all three methods of the relative amount of snow in the mountains, and of the height to which the lake will rise in midsummer. Which method will prove to be simplest or most accurate should not be decided in advance of the publication of complete data upon all three methods. At times they will all fail to forecast the actual lake level; for after the forecast the spring may be both dry and cold during the early melting period; less water may then reach the lake, which will fail to rise to the level predicted; or, the spring months may be wet and unusually warm; the snow may then go out rapidly and the lake may rise abnormally. However, experience and close observation will permit some corrections of the forecast to fit the actual weather conditions.

The apparatus used for the measurement of snow in Dr. Church's method of snow surveying is known as the "Mount Rose Snow Sampler." The idea of this apparatus originated with Dr. Church himself, but Professor S. P. Fergusson and others shared to some extent in both the invention and the construction. The sampler is a long, light, rigid tube of steel with a cutter on one end. It may be driven into the snow even to a depth of twenty feet, taking out a core of snow from the heart of the bank. The tube and its contents are then weighed on a spring balance whose dial gives a direct reading of the quantity

of water in the core. This apparatus is light, portable, and exceedingly convenient. There is every reason to believe that it is the best instrument of its kind yet invented. Dr. Church's snow sampler made possible his method of rapid and accurate snow surveying; there is a good prospect that this apparatus will be widely used both in America and other countries.

Aside from its accuracy, the great advantage of Dr. Church's method of snow measurement over other methods of estimate and measurement is in the fact that it can readily be used in the drainage basins of all the rivers of the Sierra, in the wild and uninhabitated regions at the heads of these streams. Where measurements of snowfall made throughout the winter are out of the question, and where there are no open lakes that can be used as great snow-gages, it is still comparatively easy for men to go into the mountains in the spring and measure the snow, just before the melting period sets in. This requires nothing more than the laying out of well-chosen courses and stations for snow measurement, where the snow may be measured by the same methods and in the same places every spring.

Nearly twenty thousand measurements made with this sampler have given a clear idea of the variation of density and water-content in snow banks with depth. These measurements of depth and density of snow are now being arranged in tables which will be of great assistance to others who are making snow surveys; and they will be of value to engineers in designing and protecting constructions which must resist the crushing weight of snow.

In 1913–1914, it appeared so possible that snow surveying would be useful in irrigation engineering, and Dr. Church's method appeared to be so valuable an outgrowth from his study of timber and snow, that the station decided to give substantial assistance to the perfection of the method and to its thorough testing. At the outset it seemed best to study the whole history of the snow from the earliest storms and to conduct surveys throughout the winter, which would aid in the perfection of the method and would give additional information upon the relation of timber to snow.

The thing most needed in work of this character was a stout gasoline launch with a cabin containing stove and bunks. This would enable the observer to visit any point of the lake shore in winter, and would permit rapid and accurate surveying to be done in the spring just before melting began. The station, therefore, purchased materials for such a launch, which was built at Tahoe City by Mr. Arthur L. Smith, assistant in meteorology.

The method of snow surveying has received a thorough test in the Tahoe basin especially during the last three years, when studies of the protection given by timber to snow have been in process of conclusion. Using the launch Mount Rose, provided by the station for this purpose, as a means of getting rapidly from place to place on the shore, Mr. Smith has now made three complete annual surveys over courses running from the edge of the lake back through the timber to the tops of the surrounding mountains. These three surveys, taken in connection with four others made with less perfect equipment in earlier years, have shown that good estimates of the level to which Tahoe will rise can be made weeks in advance of the begining of the melting season.

One more survey will be made at Tahoe in the coming fiscal year, 1916–1917, over the established courses. Then, because of the very thorough test which has been given to the method, it is planned to conclude this portion of the project. The University will then publish a detailed account of the method of snow surveying and of its results, with tables of snow densities, tables of losses due to evaporation, illustrations of the apparatus used, and maps of the courses over which the survey was made.

There is every prospect that these studies in snow surveying will make a useful contribution to the art and science of irrigation engineering, the science on which so much of the further extension of western agriculture must be based.

Frost Forecasting from the Summit of Mount Rose, Adams Fund, 1906–1915; Project Leader, Dr. J. E. Church, assisted by Professor S. P. Fergusson.

This study was not listed among the active projects of the present fiscal year. It terminated with the end of the fiscal year 1914–1915. An account of the project and its results was published in Station Bulletin No. 83, Technical, as a contribution from the University of Nevada to meteorological science.

In 1906, when Dr. Church began work upon this subject, his enthusiastic interest in mountain meteorology led him to think that weather conditions on a mountain peak might perhaps change before changes occurred in a valley below. For instance, in the case of frosts injurious to fruit, it might be possible to foretell the coming of frost or its severity sooner from instruments in an observatory on a mountain than from similar instruments stationed in the midst of a fruit-growing region in an adjacent valley.

A very elaborate and unusual set of continuous records covering several successive entire years, made on Mount Rose by means of an improved Fergusson meteorograph, showed that changes of temperature normally occur at the same time on the mountain and in the valley. In fact, kite and balloon records made in other institutions have shown that in the free air changes in temperature normally occur a little later at high elevations than upon the earth. Moreover, records made on Mount Washington (1871–1887) and on Pike's Peak (1873–1882) showed clearly a normal simultaneous change on the mountain and in adjacent valleys.

The Mount Rose records showed that occasionally, because of local conditions, changes on a mountain may not occur at the same time as in the valley. However, in the whole long series of records the general rule was perfectly clear; changes in temperature occur at the same time on the summit and below. Still, this was not always the case; for it might grow colder on the summit, and then later grow colder in the valley, or it might grow warmer in the valley instead.

Since there is evidently no reason for assuming that frosts in a valley can be foretold more accurately or sooner from an adjacent mountain, this project was closed by the publication of an analysis of the data made with painstaking care by Professor S. P. Fergusson.

To meteorological science this project contributes an unusually prolonged and complete instrumental record of weather conditions on a mountain peak (10,800 feet) and it contributes also an improved

form of the Fergusson meteorograph, an instrument particularly serviceable for obtaining climatic records at points nearly inaccessible in connection with forest problems.

Resignation of Professor Fergusson:

Because of the termination of the frost-forecasting studies and because of the rapidly approaching conclusion of the project in timber and snow and snow-surveying, Professor S. P. Fergusson resigned at the end of the fiscal year to enter the instrument division of the United States Weather Bureau in Washington, D. C.

Since 1911, Professor Fergusson had been connected with the projects in meteorology and forestry planned by Dr. Chuch. He came to the University of Nevada directly from Blue Hill Observatory near Cambridge, Massachusetts, where nearly twenty years' experience had fitted him for studies in this field. It was perhaps unfortunate that in Nevada Professor Fergusson's time was so fully occupied in assisting the development of projects not his own; since this situation did not give him an opportunity to show to the full the ability which his colleagues quickly recognized.

Quiet and unassuming, Professor Fergusson exercised an influence for good in the life and thought of the University. His intimate coworkers felt that he thought and spoke the truth; among mankind this is not after all so common as to be commonplace. It is sometimes a reflection in daily life of the pervading light of the scientific spirit.

Temperature Surveys in Western Nevada, Nevada State Funds, 1911-........; Project Leader, Dr. J. E. Church, assisted by F. B. Headley, in cooperation with orchard owners.

Here and there in Nevada there are spots where apples are raised, although in nearly all the agricultural regions of the State late frosts make apple orchards unprofitable. The Lewers orchard, near Franktown, Nevada, lies on a sloping bench at the foot of the Sierra; and it is fair to say that this orchard is locally as famous for the regularity of the crop as for the unusual excellence of its fruit.

Under the almost continuous sunlight of Nevada summer days, apples take on an exceedingly brilliant coloring; and the best standard varieties improve in quality and flavor, where the trees are properly cared for. Still, there are very few orchards, and these for the most part are neglected and unprofitable, because of late frosts in the spring. These frosts are so severe and so frequent that, on the whole, orchard heating gives little promise of saving the fruit.

It would seem that a careful study of temperatures in spring and early summer in districts otherwise suitable for apple growing might show other localities here and there in western Nevada where apples could be grown as successfully as they have been by Mr. Ross Lewers of Franktown, Nevada.

These considerations led to the establishment of a temperature survey, begun in 1911 by Dr. J. E. Church. The object of the survey has been to answer the following questions:

(1) How severe are the frost conditions on the bench-lands along the edges of certain valleys in western Nevada?

(2) How much orchard heating would be required to make orcharding successful in such situations?

(3) Are there benches where frosts are comparatively rare and where water is available for the irrigation of orchards?

Temperature surveys have been made along certain bench-lands on the western and southern sides of the Truckee Valley about Reno, Nevada, and upon benches in the vicinity of Pyramid Lake Indian Reservation and near the Truckee-Carson Irrigation Project at Fallon, Nevada.

Cooperative arrangements with farmers have enabled Dr. Church to secure records of temperature through several years by means of recording thermometers placed at twenty points on the benches about the valleys named. The instruments in the lower Truckee and Carson basins have been cared for by F. B. Headley, Superintendent of the Experimental Farm of the Truckee-Carson Reclamation Project. Mr. Headley is also securing for the University a very careful record from a Fergusson meteorograph in operation on that farm. The records made by these thermographs through a period of six years have not yet been tabulated and analyzed, but enough has been done to show that some of the benches are located more favorably than others in regard to frost, and that all are far better orchard sites than are locations in the valleys.

The Hazen bench near Fallon, Nevada, a region one mile wide and eight miles long, appears especially well situated for fruit growing. In the spring of 1916, although frosts destroyed apples almost everywhere in western Nevada, Mr. C. G. Swingle on the Hazen bench raised apples, peaches, plums, pears, and apricots.

This project in temperature surveying, financed from the beginning under special funds furnished by the State of Nevada, may aid in a greatly needed horticultural development.

Chemistry of Nitrogen Fixation by Alfalfa, Project 13, Adams Fund. 1910-........; Project Leader, Dr. C. A. Jacobson.

All plants require nitrogen for growth and reproduction. Most of them get their nitrogen from the soil; and where soils are deficient in this important chemical element it is supplied artificially in the form of fertilizers. It is, however, a well-known fact that the plants of at least one natural group obtain nitrogen from the air.

Alfalfa belongs to this group of plants which get nitrogen from the air through an association with certain bacteria found in little swellings or nodules on the roots. Without these bacteria, the alfalfa makes only a spindling growth and soon dies. It is, therefore, becoming common to raise these beneficial bacteria artificially for distribution in fields where alfalfa will not grow, because the right bacteria are not present in the soil.

The most important constituents of alfalfa hay are protein and perhaps certain other nitrogenous substances. It is protein which gives to alfalfa its high food value. Protein is the most expensive constituent of foods in general; that is, protein gives to meat, eggs, milk, and many other foods a value closely corresponding to their cost.

The general purpose of this project has been to state in chemical terms the nature of the process by which alfalfa gets nitrogen from the air and combines it in valuable nitrogenous compounds. More in detail the aim of these studies is to discover the various forms in which nitrogen is combined with other elements regularly found in the alfalfa

plant, in nodules, roots, stem and leaves, flowers and seeds; and to discover, if possible, the relationships existing among these compounds of nitrogen.

The use of the most refined methods of chemical analysis and study in this project can hardly fail to throw light upon a highly important process in the physiology of the alfalfa plant. It is evident that the more we know of the vital processes of plant and animal life, the better we are able to provide suitable conditions for growth and reproduction, and for preventing attacks by disease. Beyond these general benefits from such studies, it is not impossible that a more accurate knowledge of the processes by which the nitrogen of the air enters into nitrogenous compounds in the alfalfa plant may enable us to make changes in methods of growing alfalfa or in the curing and the handling of the hay, which will increase the quantity or improve the quality of the protein, and other valuable nitrogenous compounds.

It is fair at least to expect from this project definite contributions to our knowledge of plant chemistry; in the long run, we may perhaps as fairly hope for useful applications of this new knowledge. Agriculture is a purposeful control of growth and reproduction in plants and animals; do we not control best that which we best understand?

This project was outlined by Dr. C. A. Jacobson in 1910 under the Adams fund. The lack of apparatus and laboratories for studies of this character in the University of Nevada made the progress of the work so exceedingly difficult that in September, 1911, Dr. Jacobson was given eighteen months leave of absence under full salary to continue his investigations in Europe, an opportunity very unusual in American experiment station work.

Favorable conditions were found for studies of nitrogenous compounds in alfalfa in the laboratories of Professor L. Marchlewski at Cracow, Austria; of Professor A. Pictet at Geneva, Switzerland; of Professor S. G. Hedin at Upsala, Sweden; and of Professor E. Abderhalden at Halle, Germany. In 1913, Dr. Jacobson resumed active work upon this project in the University of Nevada where special laboratory facilities and equipment were provided. The Pure Food and Drug Department of the University was separated from the Experiment Station and given a laboratory of its own. The Station laboratory was reorganized, office and laboratory facilities were provided, and special apparatus and supplies were purchased to the amount of nearly three thousand dollars.

Among the new pieces of special equipment purchased by the Nevada Station for use in connection with this project in the last three years are the following:

1 Kjeldahl distillation apparatus for making twelve determinations at once;
1 Seybold oil vacuum pump;
1 Freas electric oven;
1 direct-current generator and switchboard;
1 incubating oven;
1 Kohler's transportable transmission apparatus;
1 Hoskins electric crucible furnace with rheostat;
1 Troemner scale;
1 Hilger quartz spectograph;

1 Ruhmkorff induction coil;
1 wave-length spectrometer with Nutting photometer attachment;
1 Van Slyke apparatus for amino nitrogen;
And various smaller pieces of apparatus, such as induction motors, electric hot-plate, etc.

The general method of work employed in these studies has been to extract certain substances by steeping alfalfa hay in distilled water, or in alcohol or ether, or other solvents. From the extracts thus prepared, Dr. Jacobson has separated a considerable number of substances containing nitrogen, some of which are wholly new to chemistry. Each compound has been treated as a unit; and when its character was determined, an account of the matter was published in one of the chemical journals in America or in Europe. From time to time, like-

Figure 3—Special Laboratory Equipment, Department of Chemistry, Nevada Experiment Station.

wise, new apparatus for use in these studies was designed by Dr. Jacobson, and after careful tests had been made, descriptions or the apparatus and the methods for its use were published. This project has contributed to biological chemistry a large number of papers giving new information upon the nitrogenous substances found in alfalfa hay.

Until all the combinations of nitrogen with other elements found in the alfalfa plant have been isolated from nodules, roots, stems and leaves, flowers and seeds, and until the nature of each compound has been determined, it will be very difficult to determine the origin of the various combinations and their relation to one another.

Moreover, even after the nitrogenous substances found in the hay have been separated and described, it will still be important to discover

whether they have undergone any change in the drying and curing of the hay; that is, whether they are found in the same condition and in the same relationships in the growing plant.

Alfalfa Seed Oil—In the course of the year, in connection with this project, an oil was extracted from alfalfa seed and its properties were tested.. This is a drying oil strongly resembling the best linseed oil in its properties. It has attracted the attention of paint manufacturers, who may find it useful in the manufacture of the finer paints and varnishes. When purified by a method recently worked out, it may have other uses in the arts or even in medicine.

Plant Poisons, Project 14, Adams Fund, 1909-........; Project Leader, Dr. C. A. Jacobson, in cooperation with the Department of Range Management and the Department of Veterinary Science and Bacteriology.

In connection with the study of poisonous plants, it is both important and highly interesting to determine the active poisonous principle of the plant; to know whether the poison is found in the root, the stem and leaves, or in the seeds, or perhaps in all of them. If we know the active poisonous principle of the plant, and know in what part of the plant it is found and at what stages of growth, we may be able to tell at what season animals may safely eat it. If we can feed grazing animals upon this plant before it becomes poisonous, this is a direct gain, since grazing is then apt to be injurious to the plant itself.

Besides this, it is important to know just how the poison of the plant affects the poisoned animal; what are the symptoms of poisoning. Finally, if the nature of the poison itself is known, it may be possible to devise suitable antidotes.

In short, it is plain that studies of plant poisons may lead directly to changes for the better in methods of handling live stock on the ranges and to a decrease in the serious losses due to poisonous range plants.

This study is a broad one. It forms a most excellent illustration of the purpose of the Station and of its real relation to the agricultural industry. This is so true that it is well worth examining more in detail. In the first place, the problem of the poisonous plant in the livestock industry is a real and vital one, affecting that industry seriously enough to cause great annual loss. Such a problem in the livestock industry forms the best possible foundation for a project in the Experiment Station.

For the solution of this problem the Station calls upon the methods of a group of sciences. From the science of chemistry, we expect information about the chemical nature of the poison; from veterinary science we expect a precise description and record of the symptoms shown by the poisoned animal; from the new science of range management, which has grown up in the United States Forest Service, we expect methods of getting rid of the plant or of guarding against it, and so of preventing poisoning. This is a most excellent illustration of the real meaning of experiment station work, a group of sciences working together to solve the problems which cause loss to the agricultural industry.

Equine Anemia, Project 15, Adams Fund, 1907-........; Project Leader, Dr. W. B. Mack.

For many years there has existed in Nevada a disease of horses whose nature is still unknown. This disease is known as swamp fever, or equine anemia. It is generally fatal; probably nine out of ten affected animals die. The disease may be rapid in its course; animals attacked may die within a week or a little more, but in other instances the animal may merely grow weaker and thinner through a long period extending even to two years or more. This disease has caused enough losses in Nevada to make it highly important to the livestock industry. For more than nine years it has been studied as an Adams fund project in the Nevada Experiment Station.

For many years likewise the same disorder has been a subject of study in North Dakota, Minnesota, and Texas. What appears to be the same disease has been studied in France and Germany, in Canada, and more recently in Japan. Nowhere has the cause been determined. It has proven impossible thus far either to find bacteria or other organisms which caused the disease, or to prepare any form of vaccine or serum which can be used with promise of success. Thus everywhere the problem remains unsolved. In Nevada there have been years in which the disease was rare, and material for study was not available. We have always found it impossible to inoculate healthy animals with equine anemia, and to obtain material for study in this way. Consequently, it has been necessary to wait for the development of this disease in various portions of the State. At the present time work upon this project is still in progress; and this study will be continued in the hope that we may learn at last what causes equine anemia, how it is spread, and how it may be prevented or cured.

Hemorrhagic Disease in Cattle, Project 16, Adams Fund, 1914-........; Project Leader, Dr. W. B. Mack, assisted by Dr. Edward Records.

For several years there has existed in Nevada a disease very similar to anthrax in all its symptoms, and apparently as fatal, though not as common. For the most part it has been scattered over fairly wide areas, animals dying here and there. It has occurred in epidemic form with a fairly high percentage of loss in a single herd. The most skilful work in the diagnosis of this disease failed to show the cause; the symptoms led us to suspect anthrax, but the anthrax bacteria could not be found, nor could the bacteria of hemorrhagic septicemia.

This disease occurs in the same regions where anthrax is prevalent; and the value of preventive treatment for anthrax is often obscured by the fact that after animals have been successfully made immune to anthrax they may die of this unidentified hemorrhagic disease.

As this obscure hemorrhagic disorder is common enough to cause continual losses, this project was outlined at the request of cattle owners. The object of the work is to find out if possible the real cause of the disease, and to discover the way in which it is spread, always with a view to discovering some method of prevention or cure. Thus far the problem remains only partly solved, though at present the evidence makes it appear very probable that the disease is really an

obscure form of hemorrhagic septicemia. Work will be continued upon this project until more definite information has been gained.

Hog-Cholera Serum Purification, Project 17, Adams Fund, 1915-........; Project Leader, Dr. W. B. Mack, assisted by Dr. Edward Records.

Although Nevada is a great stock-raising State, and although the prosperity of our agriculture is largely based upon our sheep and cattle industry, still there is plenty of opportunity for the production of swine. Excellent hams and bacon are manufactured in the State on a commercial scale. There is an increasing local market for all the pork products that can be procured. Hogs do well in Nevada on alfalfa pasture, but it is necessary to finish them on grain in order to produce a high grade of firm pork.

Figure 4—New Field Laboratory, Animal Disease Studies, Nevada Experiment Station.

The principal thing which has prevented the rapid growth of the hog industry in Nevada has been the disease known as hog cholera. For many years the farmers of the State have been afraid to raise hogs because heavy losses due to this disease made the hog business too uncertain. Drs. Mack and Lockett, working through the State Veterinary Control Service and the Department of Agricultural Extension in the University, have changed this situation greatly for the better. Through the use of a high grade of hog-cholera serum prepared at the University under state funds, it has been clearly shown that hog cholera can be checked and controlled. This makes the hog industry safe in the State.

With all hog-cholera serum prepared according to the standard

method, occasional complications arise. Abscesses sometimes occur at the point where the serum is injected, causing serious annoyance and some loss. Because the standard hog-cholera serum contains bacteria, blood corpuscles, fibrin from the blood, and other useless or inert matter, the dosage must necessarily be large; and it is evident that some method of purification and concentration is needed. Because of these facts, Drs. Mack and Records decided to attempt to separate the active principle from the serum and to get rid of all the useless and contaminating matter. In the course of the year, a great deal of progress has been made with this project, and already the work promises to be a genuine success. It appears now to be entirely possible to separate the active principle of the serum and thus to prepare a purified serum far more effective than the older type, and without any of its dangerous and annoying features.

Contagious Epithelioma, Project 18, Adams Fund, 1914–........; Project Leader, Dr. W. B. Mack, assisted by Dr. Edward Records.

In much the same way that hog cholera has prevented the growth of the hog industry in Nevada, contagious epithelioma has retarded the progress of the poultry industry. There is a market in Nevada for a far greater quantity of poultry products than we are producing. Moreover, the market is growing with the steady increase of population in the State.

Contagious epithelioma goes by various names. It is called roup, fowl diphtheria, chicken pox, and a number of other common names. In this disease, as in many others, the organism which causes it is unknown. It is in fact probably too small to be seen with the microscope. Besides this, it seems probable that a number of other bacteria attack fowls as soon as they become ill from attacks of the unknown casual organism.

Drs. Mack and Records, of the Department of Veterinary Science and Bacteriology in the Station, decided that it might readily be possible to check and to control this disorder by means of a vaccine prepared from the diseased tissues of chickens infected with contagious epithelioma. Tests made from time to time since 1914 have shown the possibility of the treatment; and enough thousands of birds have been treated to give the Station confidence in the method.

Biting Flies of Cattle, Project 19, Adams Fund, 1916–........; Project Leaders, J. L. Webb (U. S. Department of Agriculture), S. B. Doten (Nevada Station).

For several years past, complaints have been received of annoyance and injury to cattle grazing on mountain meadows from attacks of biting flies. These flies appear to be largely two species of horse-flies. Cattle grazing on the mountain meadows in eastern Nevada, as well as in the western portion of the State, are so annoyed by these flies in midsummer that they do not feed as they should, even on excellent pasture and do not make the gains which are to be expected from the character of the wild grasses on which they feed. The cattle bunch together when the flies are bad, stop eating and work round and round fighting flies for hours instead of feeding.

There appears to be very little available information about these

flies. Their breeding places are unknown and we know little about their earlier stages of growth. It is the purpose of the Nevada Station to gain first of all a clear idea of actual conditions, and especially to find out where the flies breed. That is, we plan to find where the eggs are laid, where the maggots live and a lot of similar facts. It may then be possible to find some way to stop the breeding of these flies. It may likewise be clearly impossible to do anything of the kind, but until we know the facts concerning these biting flies, it is utterly out of the question to suggest any means of putting a stop to their ravages.

White Sage Studies, Project 20, Adams Fund, 1916–........; Project Leader, C. E. Fleming.

One of the most serious problems in Nevada agriculture is that of the condition of the winter ranges. In central and south-central Nevada, the most important forage plant on the winter range is the white sage. On this plant sheep and cattle have fattened for a great many years—in fact, from the beginning of Nevada history. Overstocking and bad methods of range management are leading to the gradual but sure disappearance of the white sage. Stockmen all over Nevada are asking the question: What are we going to do when the white sage is gone?

On the open range, where grazing is done at will and there is no form of administration or restriction, the white sage is bound to disappear in the near future, and its disappearance will mean a very difficult feeding problem for sheepmen and cattlemen alike.

It is quite improbable that plants can be introduced from other countries to take the place of the white sage. There is little prospect that anything can be suggested by the University to improve the condition of the white-sage ranges, except where those ranges are under private ownership and control. The whole future of the livestock industry in Nevada depends upon the condition of the ranges. Some form of control or administration of the open ranges is absolutely necessary if they are to be saved. Meanwhile, there are large tracts of range in private ownership where the white sage grows. In these regions Mr. Fleming will study the habits of this plant, the conditions under which it grows and spreads, the conditions under which the seeds sprout, and the methods of grazing which are least harmful to this valuable plant. It is quite probable that methods of range management can be worked out which will show how the white-sage ranges may be used in such a way that the forage will hold its own, or even increase, instead of decreasing and ultimately disappearing.

DEPARTMENT OF AGRONOMY

PROJECT 1—IRRIGATION EXPERIMENTS

Irrigation Experiment with Alfalfa, Sugar-Beets, Potatoes, and Wheat

The object of this investigation was to determine the critical stages in the irrigation of each crop and to show at what stages of growth the plants are best able to be deprived of an application of water without causing serious injury to the crops; also to determine the amount of water required for the greatest production, and the production with small applications at different stages. With potatoes, sugar-beets, and alfalfa, a comparative study was made of the plants at different stages of growth with different methods of irrigation to determine the proper stages to irrigate these crops, and the proper amount of water to use at each application for the best results. With wheat the object was to determine at which stage or stages of growth an application of water may be eliminated without greatly affecting the yield of grain, and to determine whether or not two applications of water prove as effective as three or more applications with the same amount of water used.

Alfalfa

The irrigation experiment with alfalfa included twelve plats which were separated by levees four feet wide and high enough to prevent any overflow from one plat to another. Six-inch, nine-inch, and twelve-inch applications were made at the following stages of wilting:

(1) Before plants show need of water by dark-green color of foliage.

(2) When plants show need of water by dark-green color of foliage.

(3) When plants have suffered, as indicated by dark-green color of foliage and drooping leaves.

During the season of 1915 two crops of hay were harvested on June 23 and August 27, respectively. Samples of hay from each plat with the two cuttings were selected for a determination of moisture and nitrogen content.*

Results—The results show that alfalfa cannot be allowed to reach the wilting stages without materially decreasing the yield of hay. Where the plants were never allowed to show need of water, the yield of hay was higher with the six-inch than with the nine-inch applications of water, but slightly lower than with the twelve-inch applications, although with the latter a total of six inches more water was applied to the crop. Where the total yield was greatest the yield per acre-foot of water was low and the quality of hay was inferior to that of the other plats, due to the large proportion of coarse stems to leaves. The results clearly illustrate the importance of the time of application of water, since a gradual decrease in yield is noted in the different plats with the same applications of water as the wilting stage advances before water is applied. Alfalfa responded better than wheat, potatoes, and sugar-beets to the heavy applications of water, but not as well as did the clover the previous year.

*The nitrogen content was determined by the official method used by the Bureau of Chemistry, United States Department of Agriculture.

Potatoes

The irrigation experiment with potatoes included nineteen plats. The seed was secured from Wood-Curtis Company, Reno, Nevada. The potatoes were planted May 19, 1915, in rows three feet apart and about fourteen inches apart in the row. The potatoes were irrigated by means of comparatively deep furrows three feet apart. Three-inch, six-inch, and nine-inch applications of water were made at the following stages of growth:

(1) Before plants show a tendency to wilt.
(2) When plants show a tendency to wilt.
(3) When all leaves wilt down once.
(4) When all plants fail to revive at night.

The crop was harvested on October 1, 1915. Of the four rows in each plat the two outside rows were eliminated to prevent as far as possible any variation due to lateral diffusion of water from the adjoining plats. Three hills in different parts of each plat were selected for a chemical analysis of the starch content.*

Results—The yields of potatoes were seriously affected by dry rot, although the comparative results for the years 1914 and 1915 are in favor of the light applications, where plants do not show need of water and also at the different stages of wilting. Very little difference in yield is shown, however, where the crop receives four, six, or eight three-inch applications. Where the plants wilted down before irrigation, the potatoes made a second growth, which resulted in lowering their starch content. Plats which received over twenty-four inches of water produced very scabby potatoes.

Sugar-Beets

The irrigation experiment with sugar-beets included nineteen plats. The seed was secured from the bulk lot of the Nevada Sugar Company at Fallon. The seed was planted April 23, 1915, with a hand drill, about one and one-half inches deep, at the rate of twenty pounds per acre.

In the irrigation of sugar-beets, two-inch, four-inch, and six-inch applications of water were made at the same stages of wilting as noted under potatoes. When four leaves appeared on the plants, the beets were thinned to about ten inches apart in the rows. The crop received two hoeings, when needed, and was cultivated after each irrigation. The beets were harvested on September 20, 1915, with an ordinary walking beet-plow. Of the four rows in each plat, the two outside were eliminated as with potatoes. After plowing out the beets they were topped and weighed. Five average-sized beets from different parts of each plat were selected, weighed, and reserved for chemical analysis for sugar content and purity.†

Results: The average results for the years 1914 and 1915 indicate that the sugar-beets which are irrigated after they wilt down and fail to revive at night will not produce a profitable crop. Only slight variations in yields are shown with the two-inch, four-inch, and six-

*The starch content was determined by means of the direct acid hydrolysis. See Bulletin 107, page 52, Bureau of Chemistry, United States Department of Agriculture.

†Sugar content and purity determined by means of indirect method. See Bulletin 146, page 14, Bureau of Chemistry, United States Department of Agriculture.

inch applications, and also with the total applications of twelve, eighteen, and twenty-four inches. This is attributed partly to the lateral diffusion of moisture from one plat to another, since the plats were such a short distance apart. The sugar content of the beet was not materially affected by the stages of wilting or by the depth of application. The purity of juice in beets varied with the different stages of wilting, being greatest in the beets which received six-inch applications after the plants wilted down and failed to revive at night. The beets in this plat produced only 5.36 tons per acre, while the highest yielding plat produced 11.8 tons per acre.

Wheat

The irrigation experiment with wheat includes sixty plats. The plats were twenty-two feet wide by one hundred sixty-five feet long and were separated by levees four feet wide. Marquis wheat was used. The seed was treated for smut with a solution of copper sulphate (one pound to twenty-five gallons of water) and was sown April 15, 1915, with a double-disk drill about two inches deep, using seventy-five pounds of seed per acre. In the irrigation of the wheat, three-inch, five-inch, and seven-inch applications were made at the following stages of growth:

1. Five leaves; 3. Bloom; 5. Dough.
2. Boot; 4. Milk;

In this test the comparison was made of plats receiving an irrigation at each of the five stages of growth with plats in which an irrigation is omitted at each of the five stages; with plats in which irrigations are omitted at any two of the five stages of growth, and with plats that receive the same amounts of water in only two applications, one before and one after heading.

The wheat plats were harvested from August 9 to August 17 with the grain binder. The plats receiving the least total irrigation, when an irrigation at the milk stage was omitted, were the first to reach maturity. Four feet of grain around the outside of each plat was eliminated to prevent as far as possible any error due to seepage from one plat to another. The wheat was threshed with a small thresher operated by a six-horsepower gasoline engine. This machine made possible the thorough cleaning of the grain and caused practically no grain to be lost in threshing.

Results—One Irrigation Omitted: In this experiment the highest yield of 34.7 bushels per acre was reported where the irrigation at the five-leaf stage was omitted. The next best yield was where the irrigation at the boot stage was omitted, and the third highest yield where the irrigation at the dough stage was omitted. A difference of twenty per cent is shown in these three high-yielding plats, each of which received four seven-inch applications, or a total of twenty-eight inches of water.

Two Irrigations Omitted: With seven-inch applications the omission of irrigations at the five-leaf and dough, and the milk and dough stages showed considerable effect on the yield of grain, which in this instance was 28.5 and 27.8 bushels per acre, respectively, or about twenty per cent less than where only the one irrigation at the five-leaf stage was

omitted. In all other plats where two irrigations were omitted, a very marked decrease in yield was noted.

Where a seven-inch application was given at each stage of growth, or a total irrigation of thirty-five inches, the yield of wheat was 24.2 bushels per acre, or thirty-seven per cent less than in the plat which received only twenty-eight inches of water with the irrigation omitted at the five-leaf stage.

The lowest yields, where both three-inch and seven-inch applications were given, and where the irrigations at the boot and bloom stages were omitted, indicate that one of the most critical stages in the irrigation of wheat was between the boot and milk stages.

With four seven-inch applications, when only the irrigation at the milk stage was omitted, the yield was twenty-seven per cent less than where the irrigation at the five-leaf stage was omitted; eleven per cent less than where the irrigation at the boot stage was omitted; and six per cent less than where the irrigation at the dough stage was omitted; and eight per cent greater than where the irrigation at the bloom stage was omitted, thus giving further indication that the bloom and milk stages are very critical periods in the irrigation of the wheat crop, and the omission of applications at these stages greatly decrease the yield of grain.

Where Only Two Irrigations Are Possible: Where only two irrigations are possible, the six-inch application before heading and the twelve-inch application after heading produced the greatest yield of twenty-seven bushels per acre, or twenty-seven per cent less than the high-yielding plat, where one seven-inch irrigation was omitted at the five-leaf stage. The nine-inch and twelve-inch irrigations before heading provided more water than the crop utilized to the best advantage, which is shown by a decrease in yield of thirty-nine per cent and forty per cent, respectively. Where only two applications were given to the crop the yields were lower throughout than where a greater number of applications with the same total amount of water were given, thus indicating that only in cases of water shortage is it advisable to use only two applications in preference to three or four applications, as shown in the results of this experiment, where the yields of grain are generally much higher. At the same time where only two irrigations are possible the yield of twenty-seven bushels per acre indicates a very profitable crop.

Comparison of Three-Inch and Seven-Inch Applications: The results show a decrease in yield of 2.2 per cent with one irrigation at the milk stage omitted, and 15.2 per cent with two irrigations at the five-leaf and milk stages omitted, in favor of the three-inch applications. The remainder of the results, or eighty-three per cent, are strongly in favor of the seven-inch applications, with an average increase in yield of 28.7 per cent—a maximum increase of 87.6 per cent where one irrigation at the boot stage was omitted. Thus, the indications are that where irrigations are omitted at the five-leaf and bloom stages, boot and bloom stages, boot and milk stages, and bloom and milk stages, the three-inch applications are about as effective as twice this amount in supplying the water requirements of the crop; and furthermore the omission of these irrigations will greatly decrease the yield of wheat—

19.9 bushels per acre being the greatest production in any of the last four instances.

Soil Moisture: Where two irrigations were omitted: Before the irrigation at the milk stage the soil moisture content for the first two feet in depth was at least with 11.6 per cent where two irrigations were omitted at the boot and bloom stages; and the greatest with 16.5 per cent where irrigations were omitted at the five-leaf and dough stages. Little difference was shown where three-inch and seven-inch applications were made—1.5 per cent being the greatest average difference down to six feet in depth.

Where one irrigation was omitted: The variation of the moisture content with the three-inch and seven-inch applications was greater in many instances. The seven-inch applications at the first foot showed an increase of 14.8 per cent over that of the three-inch applications; ten per cent greater for the second foot; twelve per cent greater for the third foot; and three per cent less for the fourth foot.

Figure 5—Outfit used at the Nevada Experiment Station for Threshing Small Plats of Seed Crops, without danger of mixing the varieties

PROJECT 2—VARIETY TESTING AND CROP IMPROVEMENT

These experiments included two tests and also plat tests of several important varieties of wheat, oats, barley, corn, and sorghum (for ensilage), field peas and beans, millets, potatoes, and field beets—the object being to determine the varieties of these crops which show special adaptation to the local conditions by their hardiness and yielding capacity, and to improve these varieties by selection. By testing out these varieties in various parts of the State where the altitude and climatic conditions are different, it will be possible to determine the highest producing varieties of cereals and forage crops for all agricultural districts of the State.

Cereals

The experiment of varieties of wheat, oats, and barley included

forty-three varieties of wheat, fifty-seven of oats, and forty-four of barley. Each variety was represented by one row seventy feet long. The seed was planted April 12, 1915, about one and one-half inches deep in rows one foot apart.

Results with Wheat: In the row test of wheat varieties White Club, Chul, Colorado No. 50, Marquis (Montana), and Bluestem were the five highest producers for the years 1914 and 1915, ranking in the order named, White Club producing 53.2 bushels per acre. The average yield of Marquis Wheat (Nevada seed) was 41.9 bushels per acre, while the Montana Marquis seed produced 52.6 bushels per acre.

Results with Oats: The results show a marked increase in the production of all varieties over that of the previous year. Of the fifty-seven varieties tested, Great Dakota, Colorado Kherson, Wisconsin Pedigree No. 1, Montana Swedish Select, and Garton No. 572 were the five highest producers for the years 1914 and 1915, yielding 48.4, 48.2, 47.1, 46, and 45.2 bushels per acre, respectively.

Results with Barley: In this test Blue Ribbon, Moravian, Chevelier, California Feed, and Hanna were the highest average producers for the two-year period, in the order named, Blue Ribbon yielding 67.5 bushels per acre. The three highest producing varieties of barley were of the two-rowed type.

Forage Crops (Including Root Crops)

Results with Corn and Sorghum Grown for Ensilage: This test included the following varieties of corn: Improved Leaming, Sure Crop, Pride of Minnesota, Huron Dent, Minnesota No. 13, Pride of the North, Wisconsin Yellow Dent, Minnesota King, Northwestern Dent, Sweepstakes, Colorado Yellow Dent, Swadley's Field Corn, White Australian, Rather's Flint Corn and Parson's White Dent. Each variety was represented by four rows three hundred feet long and three feet apart. The seed was planted with a hand corn-planter about three inches deep. Furrows were made between each row for the irrigation of the crop.

Although the above hardy northern varieties of corn do not mature grain except in occasional favorite seasons, certain types produce profitable crops of forage, which provides a very palatable and satisfactory food for cattle and sheep when placed in the silo and fed in connection with alfalfa.

On September 12, 1915, a killing frost occurred which stopped the growth of all varieties, and on the following two days the crop was harvested.

The average results for the years 1913, 1914, and 1915 show the Improved Leaming, Sure Crop, and Pride of Minnesota to be the heaviest producers, ranking in the order named, the highest yield being 21,339 pounds per acre.

The experiment with sorghums grown for ensilage included the following varieties: Red Kafir Corn, Dwarf Black-hulled Kafir, White Kafir, Broom-Corn (Evergreen), Feterita, Dwarf Milo, Broom-Corn (Standard), Jerusalem and Shallu. The seed was planted May 15, 1915, with the hand planter in rows three hundred fifty feet long, three feet apart and about two inches deep. The crop was irrigated in about the same manner as the corn.

In this test the Broom-corns advanced the most toward maturity.

Although the growth was checked by a heavy frost early in September, a uniform crop of excellent heavy brush was formed with the two varieties of Broom-corn. During the years 1914 and 1915 the Red Kafir Corn and Dwarf Black-hulled Kafir were the highest producers, with 21,736 and 18,149 pounds of forage per acre, respectively.

Field Peas and Beans

In this test each variety was represented by one row. The seed was sown May 5, 1915, by hand about two and one-half inches deep in rows two feet apart and seventy feet long. This experiment included thirty varieties. The average results for the years 1914 and 1915 show the highest producer to be Colorado Stock, yielding 872 pounds of seed per acre. In 1915 the highest yielding variety was the Kaiser field pea, producing 1,225 pounds of seed per acre, as compared with 1,180 pounds of the Colorado Stock pea.

Figure 6—Method of Testing Varieties of Small Grains in Rows, Nevada Experiment Station.

The California Mexican-large bean was the only variety planted which produced seed, the average yield for the two years being 425 pounds per acre. In the plat test of the ten common varieties of field peas, the Green Canada produced the heaviest yield, or 4,071 pounds of forage per acre.

Millets

In this test the seed was planted May 5, 1915, in rows two hundred ninety feet long and three feet apart, two rows representing each variety. Ten varieties were included in this test. The average results for 1914 and 1915 show that the three heaviest producers were Siberian, Golden, and Hog, in the order named—the Siberian yielding 5,071 pounds of forage per acre.

Sudan Grass produced 2,656 pounds of hay and 1,099 pounds of seed per acre.

Potatoes

The potatoes were planted May 19, 1915, in rows one hundred sixty-five feet long and three feet apart, one row to each variety. The following varieties were represented: Great Divide, Burbank, Peerless, Early Russett, Early Ohio, Early Red, Irish Cobbler, Carmon No. 3, Rural New Yorker and Gold Coin. In this experiment a study was made of the comparative yields and quality of home-grown seed with that introduced from districts outside of the State.

Of the potato varieties, Great Divide and Burbank showed the highest average yields for 1914 and 1915, with 11,784 and 11,548 pounds per acre, respectively. These two varieties have been grown in Nevada for many years, and indicate the value of well-selected home-grown seed over that introduced from other States.

Field Beets

The beet varieties were planted April 28, 1915. The seed was sown at the rate of twenty pounds per acre, about one inch deep, in rows one hundred feet long and two feet apart. In this test the aim was to compare the values of the sugar-beet, half-sugar beet and mangel as a supplementary feed in fattening cattle, sheep, and swine.

The average results for 1914 and 1915 are in favor of the sugar-beet. Although slightly surpassed in yield by "Our Ideal" mangel, "Giant Feeding" mangel, and "Golden Tankard," a half-sugar beet, the high sugar content of the sugar-beet gives it a greater value as a food for fattening live stock. The yield of "Our Ideal" was 17,143 pounds per acre, while that of the sugar-beet was 15,390 pounds per acre—the latter containing fifty per cent more sugar than the mangel.

Cooperative Variety Tests

Variety tests of wheat and barley were conducted on the farms of A. R. Merritt and H. E. Smith of Fallon, in cooperation with F. B. Headley, Superintendent of the United States Experiment Farm at Fallon.

The test with wheat included the following varieties, yielding in the order named: Little Club, Dicklow, Rieti, Bluestem, Marquis, Sonora, Gherka, and Defiance. The highest yield was 45.2 bushels per acre.

The test with barley included the following varieties, yielding in the order named: California Feed, Hannchen, Svanhals, Kents, and Hulless. The highest yield was 42.5 per acre.

DEPARTMENT OF VETERINARY SCIENCE AND BACTERIOLOGY

In this department six projects have been conducted and all but one of them have been active during all or a portion of the year. But little has been accomplished with one project owing to a lack of material. As explained in former reports, research in infectious diseases may depend upon the natural occurrence of cases of the disease under investigation from which material for study may be secured. This is true in the project referred to—Equine Anemia. Substantial progress has been made in the other projects. Much of this work will eventually prove of value in the permanent control of the diseases in question. That must be the goal ever kept in mind in our work, if we are to serve the livestock industry, which, in the agriculture of Nevada, is paramount. The following statement by projects gives a brief account of their progress and present status, together with a brief outline of plans to be followed during the coming year. The projects under investigation are as follows:

Under the Adams Fund:

Project 15—Equine Anemia.
Project 16—Hemorrhagic Disease in Cattle.
Project 17—Hog-Cholera Serum Purification.
Project 18—Contagious Epithelioma.

Under the Hatch Fund:

Project 3—Anthrax Serum.
Project 4—Chicken Cholera.

PROJECT 15—EQUINE ANEMIA

The scarcity of material for study in eastern Nevada has continued. As a result, work under this project has been suspended there. In case of a recurrence of the disease, it will be resumed. The inoculated horses which have been under observation in Elko County for some time have been disposed of. These animals have been under observation for a long time without developing the disease with which we undertook to inoculate them. Whether the virus has gradually lost its pathogenic power as the disease has naturally declined, it is difficult to decide. In our inoculation experiments, we have apparently succeeded in reproducing the disease in some instances and have decisively failed in others. The animals above referred to have been under experiment so long that should they subsequently develop Equine Anemia, this fact would possess no significance in relation to the inoculations. For this reason they have been released from the experiment.

The disease has been recognized in western Nevada and a few clinical observations made. Blood was collected from one horse in an advanced stage of the disease and after defibrination used for the experimental inoculation of a horse. The result of that experiment so far is negative. We now hope to secure material for further study from a region where the disease is more active.

This disease is a most perplexing problem. Some investigators have expressed the opinion that the matter can be carried no further with the methods now in use. We do not believe that the project should yet be abandoned; the possibilities are not exhausted and the project will be continued.

PROJECT 16—HEMORRHAGIC DISEASE IN CATTLE

We have undertaken the diagnosis of this disease by various methods. During the year twenty-two autopsies have been performed. The autopsies included cultures and the inoculation of small animals with body fluids, organ emulsions or extracts, or cultures; cattle have been inoculated; agglutination and complement fixation tests have been applied to the sera of sick or dead animals; bacterial vaccines have been prepared and tested upon herds among which losses were occurring; a horse is being hyper-immunized that an immune serum may be tested upon infected animals; all in an effort to accurately and definitely diagnose the malady.

From these various experiments much interesting data has been obtained. Atypical anthrax, a question raised in the original outline of the project, is excluded. Anthrax occurs simultaneously with the disease in question on some ranches and evidence of double infection with the two diseases was found in two animals. However, we are dealing with a pathological entity to which anthrax bears no relation. Cultures of *Bacterium septicaemia hemorrhagica* have been isolated from two cases. Cattle were inoculated with these cultures, but the attempt to produce hemorrhagic septicemia by the inoculations failed. In all instances except two we have failed to isolate the bacterium of hemorrhagic septicemia. Mixed cultures are obtained from the carcasses in which bacteria resembling that of hemorrhagic septicemia have been observed, but it has been impossible to isolate them except in the instances noted. The gross lesions appear typical of hemorrhagic septicemia except that in a considerable proportion of our autopsies extensive infarction of the liver is found. We know of no reference to hepatic infarction in hemorrhagic septicemia. Meyer,* who is studying the disease under discussion in nearby portions of California, has described these infarctions. He is undecided regarding the diagnosis, but suspects hemorrhagic septicemia.

We have not yet sufficient data to warrant an unqualified diagnosis. But our results strongly indicate that the disease is hemorrhagic septicemia. In that case we have as yet no explanation of the difficulties of diagnosis by bacteriological methods, but the explanation will undoubtedly appear as the work progresses.

PROJECT 17—HOG-CHOLERA SERUM PURIFICATION

Work was undertaken on a project for the separation of the active principles of hog-cholera serum by fractional precipitation in an attempt to eliminate inert matter and contaminating bacteria and incidentally to reduce the dosage. While hog-cholera serum prepared by the Dorset-Niles formula confers immunity against hog cholera, many difficulties have developed in its manufacture and use in the field. It

*Meyer, Studies to Diagnose a Fatal Disease of Cattle in Mountainous Regions of California. Jour. A. V. M. A. New Series, Vol. 1, No. 5 (Feb. 1916), page 552.

is impossible to prepare this serum, which is defibrinated blood rather than serum, without a high bacterial content, even under the most favorable conditions. The use of serum thus prepared is frequently followed by severe septic processes. Such serum contains a large quantity of inert matter rendering the dose objectionably large and interfering with prompt absorption. Hog-cholera serum has fallen into disrepute in many localities, owing to these difficulties, which many serum manufacturers have failed to overcome.

It has proven possible to separate the active portion of the serum by fractional precipitation. By this method the blood corpuscles, fragments of fibrin, albumin and bacteria can be eliminated and the final product rendered sterile by filtration. The dosage is materially reduced.

Figure 7—Pens Used in Hog-Cholera Serum Purification, Nevada Experiment Station.

Difficulties in technique have arisen, but they are practically solved. One lot has been tested upon pigs by the simultaneous use of processed serum and virus, controlled by the use of raw serum from the same lot and virus with apparent success. This work will be followed by a considerable number of tests, as there are many factors entering into the project, problems which must be solved by careful experimentation. In

order to ascertain the potency of an immunizing agent the variation of susceptibility of individual animals and possible strains must be kept in mind. That variation also depends, with respect to hog cholera, considerably upon food and environment. No swill-fed animals should be used for the tests, and such tests must be conducted upon a reasonably large number of animals. After the potency of the preparation is ascertained careful experiments are essential to determine exactly what constitutes the potent fraction.

Our experiments lead us to believe that this project will prove successful and it appears probable that the expense of the process will not be prohibitive.

PROJECT 18—CONTAGIOUS EPITHELIOMA

An experiment was undertaken to determine the duration of the immunity conferred upon fowls by vaccination, and the practicability of immunizing flocks in the autumn in an effort to prevent the appearance of contagious epithelioma during the following winter in flocks upon premises where the disease usually occurs. Contagious epithelioma has appeared during the winter among the chickens upon the ranch designated in Bulletins Nos. 82 and 84 as flock No. 1. In the late summer of 1915 there were upon this ranch one thousand fowls carried over from the preceding winter which had passed through a severe outbreak of the disease and had been treated by the vaccination method; 1,298 pullets, four months old; and 286 others, ten months of age.

The lot of 1,298 pullets were vaccinated late in August, 1915. The lot of 286 were left untreated as controls. The virus used was prepared from "scab-like" lesions grown upon birds in our laboratory. It contained many bacteria, but the species associated with secondary bacterial infections in natural outbreaks of the disease were probably absent.

December 27, 1915, nine cases of contagious epithelioma were found in the vaccinated lot. Nothing was done until January 19, 1916. Upon that date 24.6 per cent of the lot were visibly infected. In the control lot we found 26.2 per cent in a similar condition. In the lot of one thousand old birds, which passed through the outbreak of the preceding winter, no cases occurred.

By January, 1916, the vaccinated lot had been reduced in number from 1,298 to 1,187 by deaths from various causes, sales, and escapes. This lot and the controls, 1,462 birds, were given the regular vaccination treatment. This work is described in detail in Bulletin No. 84. The result of the treatment was practically identical with that of the previous year. The virus used for the preparation of vaccine was the same as that used upon the flock in August, 1915.

Inasmuch as the disease appeared in these birds about four months after vaccination, attacking them to practically the same extent that it did the control lot, the result appeared to indicate that the immunity conferred by vaccination without subsequent exposure is of comparatively brief duration, much more so than in the case of birds already infected when vaccinated or severely exposed immediately afterward.

Additional experiments are being conducted which will determine the duration of the immunity conferred by vaccination and that acquired by birds in passing through an outbreak of the disease. Mean-

time too great dependence should not be placed upon vaccination as a preventive measure when exposure will not follow it within a brief time.

In certain instances the administration of vaccine has been followed by severe septic disturbances. This matter is discussed in Bulletins Nos. 82 and 84. For this reason the preparations used are not entirely satisfactory. An attempt has been made to improve them by the elimination of as many of the species of bacteria, associated with what we will for convenience term the "scab virus," as possible. The bacteria referred to are those responsible for the severe secondary infections as well as those found upon the skin and mucosæ of healthy birds. If the so-called "scab virus" is the essential cause of the disease, a preparation free from all other micro-organisms should prove an effectual immunizing agent, although it is doubtful if it would be of as much value as a therapeutic agent.

The scab virus cannot be grown *in vitro* at present. We have grown it in the laboratory upon the combs and wattles of fowls. By inoculation, after extensive scarification, lesions covering practically the entire surface of comb and wattles can be produced so that a white leghorn bird, for instance, will produce a considerable quantity. This material collected at the proper time and dried at 37°C. keeps well when stored in the ice-box. The virus of contagious epithelioma lives in such scabs for a long time. We have used such virus in the preparation of vaccines in some of these experiments. Vaccine thus prepared contains many bacteria, but probably most, if not all, of the species contained in virus collected from the lesions on the skin and mucosæ in an outbreak of the disease are thus eliminated.

In a flock, in which about twenty-five birds had died when it came under observation, we found 441 birds, 185 of which were visibly infected. There were few cases showing cutaneous lesions; but practically all of the affected birds showed severe catarrhal symptoms, involving the eyes and upper respiratory passages. Treatment was but moderately successful. Several birds died from septic processes, probably due to the bacteria in the vaccine, and recovery was slow and rather unsatisfactory. We do not feel certain that this flock was materially benefited from a therapeutic point of view, although it is probable that the spread of the infection to the remainder of the flock was checked. About forty-five birds died after treatment was begun, and it was several weeks before the flock regained good health. In our opinion, mixed bacterial infection was the principal feature involved and the vaccine used failed to reach the real source of the trouble.

Another flock consisting of 1,526 birds was dealt with subsequently. There were about seventy adult birds in the flock, the remainder being chickens from two weeks to four months of age. There were a few birds exhibiting lesions which are considered characteristic of contagious epithelioma, but the symptoms were chiefly catarrhal, and of a very severe character. Treatment with vaccine prepared from "scab virus" was but moderately successful. Improvement would occur, followed after a while by recurrence and a high death rate. After a careful bacteriological study of many of the young birds, we concluded that the principal cause of the disease was a mixed bacterial infection. From our cultures the four predominating strains of bacteria were

selected for the preparation of a bacterial vaccine, the use of which promptly ended the trouble.

These experiments are far from conclusive, but they emphasize the need for an extended study of the secondary bacterial infections. The clinical conditions we are studying are undoubtedly mixed infections; and the secondary bacterial infections may eventually prove to be of equal if not greater importance than that caused by the scab virus. It begins to appear that our "improved" vaccine was improved in the wrong direction, and that a preparation for use both as an immunizing and a therapeutic agent must consist of more than the virus contained in the "scab" lesions.

PROJECT 3—ANTHRAX SERUM

Active work under this project was not begun until some time after its approval, owing to delay in providing a building and corral in which to conduct the work. Five animals were used in the experiment, three horses and two burros. This number was used, as it is claimed that only about one animal in five will yield potent anti-anthrax serum. One horse died early in the course of hyper-immunization; the remaining four animals are being successfully treated.

We had hoped to complete the production of serum about July 1, 1916, but have been unable to do so. It will require about three months to complete hyper-immunization when serum from the animals will be collected. The production of serum together with the cost of production is all that was outlined under this project as submitted.

PROJECT 4—CHICKEN CHOLERA

Chicken cholera has appeared and been accurately diagnosed in six flocks, five of which have been treated by vaccination. In addition to this, forty young birds in flock No. 2 were vaccinated in July. This makes 479 fowls and three turkeys vaccinated during the year. The total, since the project was begun, is nine flocks, eight of which were treated. These flocks consisted of 720 fowls and three turkeys. In flock No. 1 the outbreak was promptly suppressed. Some months afterward there was a heavy loss by death in this flock and a question arose with the owner whether the disease had recurred or the birds were maliciously poisoned. He holds the latter view. We were given no opportunity to ascertain the cause of the latter losses, in fact, learned of them long afterward. For this reason the question of recurrence is somewhat clouded. In flock No. 7 vaccination was not successful, although the birds were given three treatments. In all other flocks fowl-cholera has been promptly checked and has not recurred to date.

Experiments were undertaken in the immunization of fowls by vaccination, followed by inoculation, to ascertain the degree of immunity thus conferred. We have not succeeded in thus immunizing fowls against intramuscular inoculation with fully virulent cultures. However, the clinical results apparently indicate that we are able to confer a degree of immunity sufficient to protect birds against natural infection, and it is the clinical test which must finally decide whether an immunizing agent is sufficiently potent to put an end to an out-

break. In other diseases, it is doubtful if animals which are sufficiently immunized by vaccination to withstand natural infection would prove resistant against inoculation with fully virulent cultures. Our work to date indicates that this method of treatment will eventually prove satisfactory from a clinical point of view, even if the birds treated are unable to resist artificial infection.

It was intended to terminate this project with the fiscal year, and the preparation of a bulletin was begun. We have been unable to complete it and are holding the project open for further field work pending the completion of the manuscript. The results of our studies will be published before the middle of the year.

Laboratory Facilities

The construction of a suitable field laboratory upon the Experiment Station Farm where large animals can be kept and handled makes possible the proper conduct of experiments for the study of animal diseases. Our studies, formerly conducted upon ranches in various parts of the State, are now conducted here. These buildings are exceedinly valuable to the department in facilitating its work and in the economy of time, travel, and expense effected.

DEPARTMENT OF ENTOMOLOGY

In the course of the fiscal year the work of the department was recast along more permanent lines. For several years past work had been done from time to time upon insects injurious to alfalfa. Among these insects the Desert Cutworm, *Euxoa ridingsiana*, and the Variegated Cutworm, *Peridroma margaritosa saucia*, were the most injurious, although from time to time grasshoppers have done serious damage especially to second-crop alfalfa. Recently an alfalfa plant-louse, *Macrosiphum creeli*, has at times been numerous enough to be destructive.

A number of other insects attack alfalfa in this region and, with the recent rapid advance in the price of alfalfa hay, the injury done by insects to the hay crop has become more important. For these reasons it seemed best to give a definite character to the work upon the alfalfa insects by outlining a project under the Hatch fund entitled "Insects Injurious to Alfalfa." Under this project the various insects which attack alfalfa in Nevada will be taken up one by one and studied carefully. Life histories will be worked out in detail with suitable methods for preventing insect attacks or for checking them when they occur. This project will be one of the permanent lines of work in the department for several years to come.

PROJECT 19—BITING FLIES OF CATTLE

On mountain meadows and in the higher valleys throughout the State cattle are greatly annoyed by the attacks of two or more different kinds of biting flies. Cattlemen state that this is not merely a matter of annoyance; that, in fact, the flies are so bad in some seasons and in certain Nevada valleys that cattle do not make the expected gains when feeding on the nutritious wild grasses of these valleys. In fact, at the time of day when the flies are at their worst, the cattle are kept on the move fighting flies. Often a bunch of cattle get together and work steadily round in circles fighting flies instead of feeding. It is also stated that cattle feed but little during the day when flies are at their worst and are obliged to feed at night. Naturally enough, under such conditions they do not put on flesh as they should, and this results in considerable loss.

Moreover, the biting flies frequently alight and feed upon sick animals, going from them to others in good health. Thus it appears quite probable that anthrax or the unidentified hemorrhagic disease under study in Project 16 may be spread by these insects. It is apparent, then, that the biting flies may be in reality not only sources of annoyance and loss of flesh, but also active carriers of deadly livestock diseases. After careful consideration, therefore, a project was formed entitled "Biting Flies of Cattle." It is the purpose of this project to work out the life histories of the flies, find under what conditions they breed and where, and to discover if possible some means of greatly reducing their numbers. This may, of course, prove to be out of the question. At any rate, however, nothing can be done until more is

known about the earlier stages of growth of these flies. This project is considered of sufficient interest by the United States Department of Agriculture to warrant their setting aside special funds for its support; and plans have been made for a cooperative investigation of the biting fly problem in the fiscal year 1916–1917. A representative of the United States Bureau of Entomology is to be detailed to study this problem in Nevada in cooperation with the Department of Entomology in the University of Nevada.

DEPARTMENT OF METEOROLOGY

ADAMS FUND CONCLUDED—FORECASTING FROST FROM MOUNTAIN TOPS

The results were published in Station Bulletin No. 83, Technical, The Value of High-Level Meteorological Data in Forecasting Changes of Temperature—a Contribution to the Meteorology of Mount Rosé, Nevada—and the project was closed. However, the many by-products bearing on mountain meteorology and climatology will be analyzed and published as opportunity is afforded. The Mount Rose and base stations will be maintained temporarily by the University in order to procure data essential to the snow studies and the temperature survey.

PROJECT 12—SNOW STUDIES AND SNOW SURVEYING

(a) The Protection Given by Forests to Snow.

(b) Snow Surveying as a Means of Forecasting Water Supplies.

Field work connected with the study of the conservation of snow is nearly concluded, except that measurements in evaporation are being continued as a part of the study of forecasting water supplies.

The forecasting of water supplies has at present two aspects: (1) the economical and accurate measurement of the amount of snow available in the early spring for irrigation, and (2) the causes of abnormalities in the run-off.

A method for the economical and accurate measurement of snow seems now to have been attained in the Method of Seasonal Percentage, which involves the maintenance of a few fixed courses in typical parts of the watershed as a basis for computing the relation of the annual snow cover to normal.

The problem of abnormalities of run-off became acute during the present year, when despite the fact that the snow cover was 155 per cent of normal, the level of Lake Tahoe rose only 110 per cent. While the scanty precipitation during April and May was responsible for eighteen per cent of this loss, other factors, particularly the checking of run-off by freezing, were apparently responsible for the remainder. The losses over the watershed supplying Salt Lake City amounted to thirteen per cent. The presence of the large lake in the Tahoe Basin increased the relative losses for the latter watershed.

To procure reliable data on evaporation from snow, evaporation studies were made during the winter and spring at Tahoe City (6,225 feet) and at Marlette Lake (8,000 feet.) Continuous measurements for eight days were also made in May and June on the flank of Mount Rose at the altitude of 9,000 feet. It was hoped that these measurements might be continued long enough to give some idea of the average evaporation losses over the entire watershed and to formulate a factor of correction to apply to forecasts. To supplement these measurements a floating pan is being maintained in the outlet of Lake Tahoe.

Because of the excessive snowfall and the slow run-off, three snow

surveys were made during the winter and late spring. The data procured will be used as a standard by which to judge other abnormal seasons.

A continuous record of humidity, temperature, pressure, and wind velocity and direction is being procured by means of a meteorograph placed in a central position on Observatory Point for the purpose of determining the relation of the weather to the losses that occur on the snowfields and in the Lake.

It is believed that the major losses in run-off can be detected in this way and corrections be made immediately in the forecast. This is particularly desirable in the case of large reservoirs like Lake Tahoe, where the maximum level is attained late and it is essential to conserve

Figure 8—Dr. Church's Method of Studying the Evaporation of Snow, Mount Rose Weather Observatory.

the largest amount of water possible without doing injury to the property along the shores.

Cooperation

Close cooperation has been effected between this department and the Reclamation Service in the joint use of employees, headquarters, boats, and equipment.

As already mentioned, the United States Weather Bureau has installed an evaporation pan at Lake Tahoe. It has also cooperated in the snow surveys in the Tahoe Basin and has established additional courses there and inaugurated snow surveys in the Carson and Walker Basins.

Temperature Surveys in Western Nevada

Under cooperation with the Bureau of Plant Industry, the temperature survey has been extended to all parts of the Truckee-Carson Project with striking results.

Although the present season was destructive to nearly all fruits in Nevada, at the Swingle Ranch on the western bench of the Project, apricots, cherries, pears, apples, and other fruits were a full crop. Continuous temperature records were obtained at two points along this bench as well as at Pyramid Lake, where conditions seemed favorable to fruit. However, on the bench the temperature did not fall below the danger point, while at Pyramid Lake in the lowest part of the basin the temperature fell to 22°F. This benchland is approximately one mile by eight in size and is well adapted in soil and nearness to railroads for the raising of fruit. This escape from frost was not abnormal, for the minimum temperatures in this belt are among the highest in the northwestern part of Nevada.

As during the previous year, the fruit at Lake Tahoe escaped to the extent of at least a half crop. Fruit was also found on the foothills near Genoa (4,700 feet) in Carson Valley, and at approximately 6,000 feet at Virginia City. One tree of late apples bore a half crop at Pecetti's Ranch at 4,700 feet. On the other hand, the fruit in the orchards at Verdi (4,900 feet) and at Lewers's Ranch (5,500 feet) near Franktown was almost entirely destroyed—only twenty-seven apples coming to maturity in the latter orchard. Evidently, the storm, whose clearing destroyed the fruit in the lowlands, developed into a freeze at 5,000 feet and destroyed all of the fruit and blossoms sufficiently developed to be sensitive. The blossoms at Virginia City and Lake Tahoe escaped merely because they were but little advanced beyond the dormant stage.

DEPARTMENT OF CHEMISTRY

PROJECTS 13 AND 14—CHEMISTRY OF NITROGEN FIXATION BY ALFALFA AND PLANT POISONS

Work has been in progress in this department upon Station Projects 13 and 14, Adams Fund, as outlined in last year's report—Project 13 being the investigation of alfalfa with relation to the fixation of atmospheric nitrogen; and Project 14, that of the active principles existing in local poisonous plants.

The work on alfalfa-seed oil discussed in last year's report has been compiled and published in the Journal of the American Chemical Society, Vol. 38, page 480. Judging from the number of requests for samples, it appears that this oil may have some commercial value. At the request of Dr. L. P. Nemzek, special technical representative of the Paint Manufacturers' Association of the United States, a sample of alfalfa-seed oil was sent for the purpose of testing the oil as a possible substitute for linseed oil in the paint industry. At the conclusion of his tests, Dr. Nemzek submitted a report from which I take the liberty of quoting the following paragraph:

"Careful check tests for drying properties which were made with the second sample you forwarded showed that the oil was the equal at least of raw linseed. As a matter of fact, in all of the tests which we made, it set to touch and dried just a little faster than raw linseed. As different lots of raw linseed oil will vary somewhat for the time required to dry, I think it is safe to state that alfalfa-seed oil will dry in the same length of time that linseed oil requires."

Professor Charles Baskerville of the College of the City of New York has worked out a new process for refining and purifying vegetable oils, and at his request a sample of alfalfa-seed oil was sent for the purpose of submitting this oil to the process in question. After the oil had thus been treated a sample was returned, which showed that the oil possesses a transparent yellow color instead of the original brownish red and is freed from free fatty acids as well as various impurities and coloring matters. In the purified form, alfalfa-seed oil might possess commercial value in the drug or perfume industries. No tests have been made along this line, however.

Two additional investigations correlated with the work on alfalfa-seed oil have been compiled and published in the Journal of Biological Chemistry, Vol. 25, pages 29 to 61. They are entitled "Solubility Data for Various Salts of Lauric, Myristic, Palmitic, and Stearic Acids," and "The Separation of Lauric and Myristic Acids from Each Other and from Mixtures of Other Fatty Acids." The characterization of alfalfa-seed oil has been rendered more complete by the investigations mentioned and they are investigations growing out of the work on alfalfa-seed oil, although they are in themselves not directly connected with Project 13. The former paper contains thirty-three tables of solubilities of the lithium, magnesium, beryllium, barium, lead, and silver salts of lauric, myristic, palmitic, and stearic acids in two or more of the following solvents: water, ethyl and methyl alcohol, ether, benzine, ethyl acetate, methyl acetate, amyl alcohol, and

amyl acetate, chloroform, and acetone at room temperature 25°, 35°, and 50°, whenever the boiling point of the solvent permitted. This solubility work led to the following conclusions: The solubility of all the salts of the four fatty acids in the various solvents tried is only slight; but considerable differences are found, not only among the several salts in the same solvent, but also for the same salts in the different solvents.

The solubility in any case rarely exceeds one per cent, but was found to vary between six per cent and virtual insolubility. Methyl alcohol was found to be the best general solvent for this class of substances.

The lithium salts were found to be about three times as soluble in methyl alcohol and acetone as the magnesium salts, while the latter are more soluble in ethyl alcohol than the former. It is also seen that the lithium salts are a great deal more soluble in water than the magnesium salts, but the difference is not in a constant ratio for the different temperatures. The beryllium salts of the fatty acids were made, but contrary to expectations the basic salts rather than the normal were formed.

To summarize the results of the second paper, it should be said that a method has been discovered for separating lauric acid from a mixture of the higher fatty acids by the greater solubility of its lithium salt in water and a method for the separation of myristic acid from the other higher acids by the difference in solubility of their magnesium salts in fifty per cent alcohol.

The work on alfalfa saponine mentioned in last year's report has been continued, but no technical paper has yet been published on the subject.

Under Project 14, Adams Fund, Technical Bulletin 81 of this Station has been published. It includes a compilation of the most trustworthy literature on the subject of Water Hemlock (Cicuta). Besides a complete chemical discussion, as published in the Journal of American Chemical Society, it contains a comprehensive botanical and toxicological discussion. Furthermore, it contains a list of typical cases of poisoning of frogs, rabbits, cats, dogs, cattle, horses, and man. With the publication of this bulletin the work on this particular poisonous plant terminated.

During the year cases of poisoning have been reported from Death Camas, Lupines, and Golden Rod. Some material of each of these plants was collected, extracted, and subjected to analysis. One or more crystalline alkaloids from Death Camas have been isolated, but, since an insufficient quantity of material was at hand, the work was not completed. An alkaloid-hydrochloride was isolated from the seeds and pods of the Blue Lupine, but this also awaits further investigation.

The alcoholic extractions of the Golden Rod did not yield an alkaloid, having poisonous properties, but some of the leaves of the Golden Rod were collected and fed to a sheep which showed that a poisonous substance was present. What the poison is we have not yet determined.

In order to make the chemical work conform as much as possible to the immediate needs of the agriculture of the State, it has been decided to work more particularly along the lines of the poisonous character of the plants causing the greatest trouble to stockmen at different stages of growth, rather than to emphasize the chemical side of the poisonous principles themselves.

PROJECT 11—RELATIVE FEEDING VALUE OF CROPS OF ALFALFA

Under the Hatch Fund, an entirely different line of work with alfalfa has been started during the past year. It is the investigation of the difference in chemical composition of the different cuttings of alfalfa obtained from various localities of the State. Stockmen and ranchers have reported a marked difference in feeding value of the different cuttings of alfalfa and it became pertinent to investigate what chemical differences there might be in the different crops of alfalfa grown under Nevada conditions.

Between forty and fifty samples of different cuttings of alfalfa were secured and more than half of these have been analyzed, but the work is not far enough advanced for drawing any definite conclusions.

Wherever possible, the samples were selected from such ranches as are included in the dairy tests of the Extension Department. In this way the chemical analyses can be compared with actual feeding results and it is hoped that when the work is completed, generalizations of value to the State can be drawn.

For the coming year, it is planned to continue the latter phase of the alfalfa investigation; that is, with regard to the chemical composition of the different cuttings taken in connection with actual feeding tests.

Mr. August Holmes, who has been connected with this department for the past two years, left at the end of August of the present year to take up commercial work at Baltimore, Maryland. No assistant was secured to take his place, but the department has had the services of three students for short periods each week throughout the school year.

A motor generator and switchboard were purchased this year; and the chemical laboratory of the Station is now well equipped to do almost any kind of chemical work along the lines of agricultural and biological chemistry.

DEPARTMENT OF RANGE MANAGEMENT

The Department of Range Management was created during the latter part of February, 1916, when Mr. Fleming resigned from the United States Forest Service and took charge of the newly created department.

His efforts at first were entirely confined to obtaining office and field equipment necessary for properly conducting the new line of work. As a result the office is now equipped with furniture for two permanent men and several assistants. For the pursuance of detailed field studies, the department has practically all of the necessary equipment—such as quadrat straps, compasses, pack outfits, etc.

After the field and office equipment was acquired, Mr. Fleming spent considerable time in the preparation of project working plans. These cover the following projects:

Project 6—Poisonous Range Plants;
Project 7—Reestablishment of Native Range Forage Plants;
Project 8—Relative Importance of Native Range Forage Plants;
Project 9—Introduction of Foreign Range Forage Plants;
Project 10—Carrying Capacity of the Range;
Project 20—White Sage Studies.

After these working plans were prepared, Mr. Fleming left for the field and until July 1, 1916, spent most of his time in the southern part of the State making a reconnaissance of the grazing conditions. Practically all of the range from Goldfield to Las Vegas south of the Las Vegas and Tonopah Railroad to the State line of California was covered; also north of the Las Vegas and Tonopah Railroad, the range from Amargosa to Skull Mountain and Yucca Pass.

Practically speaking, all of the range south of the railroad track is absolutely devoid of valuable range plants, except around Ash Meadows. The grazing problem in this district is the revegatation of the range, or rather the introduction of some species of plant growth valuable for grazing. The introduction of such a plant at the present time seems a remote possibility.

North of the track there are large areas of range supporting grasses, weeds, and browse, having a ground cover of between .3 and .4 density. However, this range is all dry and at the present time cannot be utilized even during the winter, due to a lack of sufficient amount of snow for the stock. This range at the present time has a carrying capacity of approximately fifty acres cow year long. Due to the dryness of the forage during the summer months, this range is only adapted to the grazing of cattle.

The big grazing problem on this range is the development of stock watering places and the setting aside of a sufficient acreage of range, in order to determine whether or not it is profitable to establish wells and grow stock. The stock would be handled on a year long basis and if it is found profitable to water this range for stock, it means the development of large areas of range now going to waste. There is one range alone

which has an estimated carrying capacity of ten thousand head of cattle, which in itself means quite a revenue.

All of the land in this vicinity is absolutely valueless for the production of agricultural crops and, therefore, it is essentially a stock raising proposition. If the water can be developed and the range has a continuous carrying capacity of fifty acres year long, it will develop into a valuable stock raising district. However, there are the two experimental aspects of the situation and these should be investigated.

During the month of June Mr. Fleming spent several days on the Mount Rose and Peavine Ranges with a view of locating areas suitable for the study of poisonous plants. Undoubtedly these two ranges offer exceptional possibilities for a detailed study of the habits of poisonous plants causing loss in the State of Nevada.

PUBLICATIONS OF THE STATION FOR THE FISCAL YEAR 1915–1916

Bulletins and Reports.

No. 81—"Water Hemlock (Cicuta)," by Dr. C. A. Jacobson. Accepted for publication, March, 1915.

No. 82—"The Control of Contagious Epithelioma in Chickens by Vaccination," by Drs. W. B. Mack and Edward Records. Accepted for publication, June, 1915.

No. 83—Technical, "The Value of High-Level Meteorological Data in Forecasting Changes of Temperature—A Contribution to the Meteorology of Mount Rose, Nevada," by S. P. Fergusson. Accepted for publication, June, 1915.

Annual Report of the Board of Control for the Fiscal Year ending June 30, 1915.

Technical Papers.

"Umbilical Necrobacillosis in Lambs," by Dr. W. B. Mack; American Veterinary Review, August, 1915.

"Some Aspects of Scientific Research," by Dr. C. A. Jacobson; Science, October, 1915.

"Need of a Large Government Chemical Institution for Chemical Research," by Dr. C. A. Jacobson; Journal of Industrial and Engineering Chemistry, January, 1916.

"Alfalfa-Seed Oil," by Dr. C. A. Jacobson; Journal of the American Chemical Society, February, 1916.

"Separation of Lauric and Myristic Acids from Each Other and from Mixtures of Other Fatty Acids," by Dr. C. A. Jacobson; Journal of Biological Chemistry, March, 1916.

"Solubility Data for Various Salts of Lauric, Myristic, Palmitic, and Stearic Acids," by Dr. C. A. Jacobson; Journal of Biological Chemistry, March, 1916.

"Division of Labor and Chemical Research," by Dr. C. A. Jacobson; Scientific American, July, 1916.

"Importance of Scientific Research to the Industries," by Dr. C. A. Jacobson; Science, September, 1916.

"Horticulture in Nevada," by Dr. J. E. Church, Jr.; Standard Cyclopedia of Horticulture (Bailey).

"Science Notes: Frying Frozen Meat; Face Masks for Use on Snow Fields," by Dr. J. E. Church, Jr.; Scientific American.

"Snow Surveying: Its Problems and Their Solution," by Dr. J. E. Church, Jr.; Monthly Weather Review.

FINANCIAL STATEMENT

C. H. GORMAN

Nevada Agricultural Experiment Station

IN ACCOUNT WITH

The United States Appropriations, 1915–1916

Items	Hatch Fund	Adams Fund
Debit		
To balance from appropriations for 1914–1915	$0.00	$0.00
Receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1916, under Acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund)	15,000.00	15,000.00
Credit — Abstract		
By salaries — 1	$8,277.22	$12,059.72
By labor — 2	1,844.06	204.80
By publications — 3	142.88	------
By postage and stationery — 4	282.74	30.40
By freight and express — 5	3.57	6.00
By heat, light, water, and power — 6	53.70	288.11
By chemicals and laboratory supplies — 7	200.34	775.22
By seeds, plants, and sundry supplies — 8	295.04	271.94
By fertilizers — 9	None	None
By feeding stuffs — 10	413.79	408.76
By library — 11	134.84	32.55
By tools, machinery, and appliances — 12	408.72	28.18
By furniture and fixtures — 13	723.51	None
By scientific apparatus and specimens — 14	420.45	331.27
By live stock — 15	208.17	525.80
By traveling expenses — 16	971.30	37.25
By contingent expenses — 17	22.50	None
By buildings and land — 18	601.67	None
By balance	0.00	0.00
Totals	$15,000.00	$15,000.00

We, the undersigned, duly appointed Finance Committee of the Board of Regents, do hereby certify that we have examined the books and accounts of the Nevada Agricultural Experiment Station for the fiscal year ended June 30, 1916; that we have found the same well kept and classified as above; that the balance brought forward from the preceding year was $0 on the Hatch Fund and $0 on the Adams Fund; that the receipts for the year from the Treasurer of the United States were $15,000 under the Act of Congress of March 2, 1887, and $15,000 under the Act of Congress of March 16, 1906, and the corresponding disbursements $15,000 and $15,000; for all of which proper vouchers are on file and have been by us examined and found correct, leaving balances of $0 and $0.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said Acts, respectively.

(Signed) A. A. CODD,
[SEAL] JOHN J. SULLIVAN,
J. W. O'BRIEN,
Finance Committee Board of Regents.

Attest: (Signed) C. H. GORMAN, *Custodian.*

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AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Annual Report of the Board of Control for the Fiscal Year Ending June 30, 1917

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

CARSON CITY, NEVADA
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
1918

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NEVADA AGRICULTURAL EXPERIMENT STATION

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*Resigned September 1, 1916.

REPORT OF THE DIRECTOR

THE FUNDS AND THE FIELD OF WORK OF THE NEVADA AGRICULTURAL EXPERIMENT STATION

The Nevada Agricultural Experiment Station is supported almost entirely by two federal funds, the Hatch Fund ($15,000 per annum) and the Adams Fund ($15,000 per annum). These two funds are sent out quarterly from Washington, D. C.; and a report showing how they have been expended is issued annually from the State Printing Office. Little assistance has been asked for from the State of Nevada. For several years past, however, the Station has received a fund amounting to approximately $1,000 per annum from the State Public Service funds of the University. This small state fund is applied in part to the preliminary study of problems before they have been accepted as projects by the Federal Government.

There are, of course, a great many problems in the agriculture of the State, problems which can be solved by scientific study. With the limited resources of the Station it is almost out of the question to undertake any very large number of projects at one time. More could be done, of course, if state funds were drawn upon more heavily; and there is good reason to believe that the State would willingly support the Experiment Station work in Nevada; but for the past four years it has seemed more desirable that all available state funds should be applied to the development of the Division of Agricultural Extension, which promises to be of great assistance to farming in this State.

That is, since the funds available in the State of Nevada are limited, it has seemed more desirable in recent years to develop a new organization for spreading information and stimulating agricultural progress in the State than to assist an established organization for the scientific study of agricultural problems.

The Relation of Experimental to Extension Work

The foundation upon which class-room teaching in agriculture and extension teaching by specialists in the field alike must rest, is the foundation of accurate and painstaking experimental tests. Unless a man knows something of the evidence upon which his assertion rests, he is not in a position to be certain that he is telling the entire truth. Every doctrine concerning the fertilization and preparation of the soil, the care and housing of animals, everything that is taught concerning the treatment of insect pests and plant diseases, or concerning the prevention and cure of animal diseases, alike must be founded on carefully executed series of experiments in order to rest upon a safe basis of evidence. Therefore, it was necessary that the experiment stations of all the States should be at work for years before they could supply to teachers or to extension workers living in farming communities a series of statements of fact which it would be safe to teach.

In the earlier years of experiment station work it was found necessary at times to take the station men away from their experiments and to place them in the field as farmers' institute lecturers or in other capacities as extension workers. At the present time, however, when the extension work is adequately financed and is making rapid and substantial progress in Nevada as in other States, it is both desirable

and necessary that the experiment station men shall work vigorously within their own limited field of effort, which is the conduct of experiments to discover unknown things.

It is essential, however, that the experiment station men shall place their work on such a basis that much of it, perhaps the greater part of it, shall be done outside the University. Thus, in the Department of Range Management it is necessary that the greater part of the work shall be done upon the range. In entomology, likewise, the insect problems of the State cannot be studied entirely at the University, and for this reason a field station for the study of one problem has been established in Antelope Valley. Field tests in the use of water, and field trials of varieties of crops made upon the experimental plots at Reno, must be tested later throughout the principal farming sections of the State in order to be of the utmost value. In bacteriology and veterinary science, likewise, it has been found necessary to establish from time to time field stations for the study of special problems. Thus between the years 1908 and 1916 a field station for the study of swamp fever (equine anemia) was maintained near Lee, Elko County, Nevada. The Veterinary Department is now maintaining a field station in Antelope Valley for the study of hemorrhagic septicemia. On the other hand, most of the chemical work of the Nevada Station must be done upon the University campus and material must be brought in from the outside to the local laboratory, since a chemical laboratory requires highly specialized equipment and appliances which cannot be readily set up for work in a field station.

Because of the rapid growth of agricultural extension under Director C. A. Norcross, the Experiment Station is now able to devote its entire energies to experimental studies which constitute its own proper field of work. It is the duty of the Experiment Station to discover facts. It is the function of the extension service to teach these and other facts. In each state the extension service is a clearing house for information discovered in all the States. No one experiment station can make in any one year any very large contribution to human knowledge. The contribution made by the whole group of experiment stations is large and increasingly important. Thus, it is essential that extension workers everywhere shall keep in close touch with the work done in the experiment stations of all the States, in order that they may know what new things have been discovered which may apply toward agricultural progress in each of the States.

On the other hand, since the extension workers cover intimately every nook and corner of every State—meeting all classes of people in the farming industry and coming into direct contact with their problems—it is evident that the extension workers are in a position to obtain valuable information concerning the extent and gravity of agricultural problems. Thus, while the work of the experiment stations contributes largely to the success of extension work, it is equally clear that the extension workers are in a position to repay their debt by discovering problems which demand solution and by forming accurate estimates of the extent and importance of such problems. The closest reciprocal relation between the two divisions thus becomes exceedingly necessary.

Some time in the future it may be possible so to arrange the organizations that temporary exchanges of workers between the two divisions may be brought about. Thus, occasionally a man or woman of ade-

quate special training for experimental work may be found in extension service, or an experimenter who has ability as a field teacher may be found in an experiment station laboratory.

It is of great value to an extension worker to understand the experimental method and to realize how much patient, exact, and prolonged work is required to establish a very simple set of facts. It is of value also to an experiment station man to come into close contact with farming people and also to see their needs and problems as the needs and problems of an industry—practical, concrete problems for which a definite, practical, and concrete solution is demanded. However, it is not unlikely that it may prove better for the personnel of the two organizations to remain for the most part distinct; since only rarely can an experimenter, working ardently upon his special problem, leave it before a solution has been reached and turn his energies even temporarily into another field of work. For instance, a man working upon a chemical problem or a problem in bacteriology or some problem of plant or animal disease must in general see his problem through before he will be in a position to leave it without great loss or injury.

POLICY OF THE NEVADA STATION

Since the year 1913–1914 an active effort has been in progress so to rearrange the program of the Nevada Experiment Station as to adapt it more definitely to the needs of the State. This has been largely the result of an awakening interest in the work of the Station on the part of livestock men. The steady increase in the value of cattle and sheep and the slow but inevitable decrease in range pasturage have led livestock owners to introduce modern business methods and to watch every source of loss.

The land hunger that is being felt all over the United States has caused owners of unproductive tracts of sagebrush to seek water for irrigation. The leading problems of agriculture in Nevada are those connected with the use of water in crop production and with losses due to animal diseases and poisonous plants. Any large increase in the acreage of farm crops in the State can be brought about only by a wiser use of water in irrigation. Such an increased acreage probably means a larger expense in the handling of the water, and this is apt to mean that more valuable crops must be grown. This in turn will bring about an increase in population and a decrease in the size of the farms.

Thus the Station must inevitably engage in two distinct lines of effort. We must study the problems of the livestock industry less with a view to the extension of that industry than with a view to rendering it more profitable by preventing unnecessary waste and loss. We must study the use of water in irrigation with a view to the utmost extension of the irrigated area.

There is every prospect that for a great many years to come sheep and cattle will be the most valuable agricultural products of the State of Nevada, and that they will lead all other products by an immense margin. This is because the State is dry and mountainous. It is ribbed with mountain chains running north and south over the entire area of the State with desert valleys lying between the mountains.

A few streams, the Truckee River, the Humboldt, the Carson, and the Walker, furnish a very considerable amount of water for irrigation. It has been used wastefully in almost every valley—often to

the injury of the irrigated lands and almost always to the distinct injury or ruin of the other lands lower down in the same valley. Early in the history of the State all the water in the streams was appropriated, often many times over. These filings led to the belief that all available water was being used in irrigation. Still, every year new lands tributary to these streams have been broken up and put into cultivation. That is, the irrigated area has steadily increased, with no increase in the available water. The results of experiments conducted for the last four years by Dean C. S. Knight of the Nevada Station, taken in connection with excellent experimental work done by the Utah Station and stations in other Western States, all indicate that even now our present Nevada acreage under irrigation can be at least doubled, with nothing but benefit to the entire irrigated area.

There is need, therefore, of a long series of careful experiments showing the actual water requirements of the principal crops grown in Nevada. This work, of course, must be done first on the trial plots at Reno. Certain conclusions can be reached here which are of the utmost importance because all of the conditions of the experiments are under complete control. Soils and climatic conditions differ, however, in every valley of the State; and any conclusions based on the experiments at Reno must be widely tested in other valleys before recommendations can safely be made. It will be necessary to study soils and their chemical and physical conditions and to study local methods of applying water and the chemical make-up of local water supplies. If, however, this line of work in the Nevada Station leads to any considerable increase in the irrigated area, or to a wiser and more conservative use of our limited water supply, it will be of wide benefit and will repay its cost many times over.

The Station is studying losses of live stock due to diseases, in preference to studying the usual feeding, breeding, and marketing problems of the animal industry, because the livestock owners of Nevada regard the problems connected with feeding, breeding, and marketing as business matters which they can handle themselves. Disease, however, presents problems which require the most refined laboratory methods for their solutions. The rapid growth of the Department of Veterinary Science has been made in direct response to an earnest demand from owners of cattle and sheep who have heartily endorsed the policy of the Station in this regard.

The problems of the range have been approached in the Nevada Station in past years from the standpoint of botany. Thus we have studied in earlier years the relative importance of the native range forage plants, have classified these plants, and have obtained through the work of Messrs. Hillman, Kennedy, and Dinsmore a large amount of valuable information concerning their feeding value. This work laid a foundation of the utmost importance for work of another type.

It became evident that the problems of the range must be approached from the standpoint of the handling of live stock on the range in such a way that the native pasturage can be used without injury to its continuous carrying capacity. A man fitted to undertake range studies of this type is a very hard man to find. He must know the range as the sheepherder and cowboy alone know it. He must have ridden after cattle and tramped after sheep for months and years and must have

seen the effects of overgrazing and of bad methods of handling stock as business problems. He must also be a trained botanist, able readily to distinguish the various forms of plant-life from one another, to recognize the poisonous forms at a glance, and to appreciate equally the conditions under which the nutritious and valuable kinds will be reproduced and spread.

Very admirable work has been done in this field by the United States Forest Service under Mr. J. T. Jardine in charge of grazing studies in that service. A group of men working under Mr. Jardine have shown that it is not only possible to use range continuously without injury, but that in many instances range that is used for sheep and cattle pasturage will produce a steadily increasing amount of forage year by year if the methods of handling live stock are of the right type. In 1916 the University of Nevada secured Mr. Jardine's first assistant, Mr. C. E. Fleming, who was then in charge of the Jornada Grazing Reserve in New Mexico.

Since coming to the Nevada Experiment Station, Mr. Fleming has traveled many hundreds of miles in the saddle and on foot over Nevada ranges in order to gain a first-hand knowledge of conditions. He is already in a position to make recommendations of great value. First of all, he now urges the stockmen of the State to drop at once the idea that there is somewhere in the world a plant or a group of plants that can be sown broadcast over the Nevada ranges to grow luxuriantly and restore the ranges to their former carrying capacity. There is no probability that such a plant will ever be discovered. There is no source of supply from which seeds of any value for this purpose can now be purchased. Everything points to the conclusion that the best forage plants for Nevada ranges are the original bunch-grass, sages, weeds, grass, and browse which are native to this State.

The Nevada ranges must simply be better cared for than they are now cared for outside of forest reserves, or else the State's output of cattle and sheep will decrease steadily instead of increasing as it should. Many livestock owners now advocate the creation of grazing reserves including all the public lands of the State suitable for grazing and not now included in forest reserves. Such federal grazing reserves under complete and intelligent control could readily be so administered as to put the livestock industry of Nevada upon a safe and profitable basis. On the whole, Mr. Fleming's observations have led him to feel that little or nothing can be done by any human agency toward the improvement of the public range lands so long as they lie open to competitive grazing by cattle and sheep. Much can be done, however, on the open range toward the introduction of methods of handling sheep and cattle which will diminish the present degree of injury and largely reduce losses due to poisonous plants.

The principal problems, therefore, at the present time in the agricultural industry of the State of Nevada which may be solved by experimental methods are the problems connected with the wise use of water in irrigation and those connected with animal diseases and plant-poisoning, and finally the important problems connected with the range forage throughout the State. These three groups of problems have been analyzed into a set of projects which are given in brief further on.

A later section of this annual report presents the work of the various

scientific departments in which these station projects are under study. The policy of the Nevada Agricultural Experiment Station may be stated very briefly as follows:

First—To choose a few vitally important problems in the agriculture of the State; to finance the study of these problems adequately; and, having secured the best men and the best facilities available, to study these problems year by year, working always toward a solution.

Second—To maintain consistently a high standard of scientific investigation in all the project work of the Station in order that conclusions reached may be based upon valid evidence.

PROJECTS OF THE NEVADA STATION

Project 1—Irrigation Experiments. Hatch Fund. Project Leader, Dean C. S. Knight, assisted by J. B. Menardi. Begun in 1914; to terminate in 1919.

The condition which sets a limit to farming in Nevada is the lack of water. Throughout the State there are large areas, whole valleys oftentimes of very considerable extent, where the absence of water makes agriculture impossible. Dry farming is still in the experimental stage. There are undoubtedly parts of the State where dry farming will be successful. In other regions in Nevada the rainfall occurs at the wrong time of the year, or is so deficient in quantity as to make the success of any form of dry farming problematical. The adaptation of crops to arid conditions and the steady improvement in methods of conserving water in the soil should lead to a considerable extension of the region dry-farmed in Nevada. Even then, however, the problem of how to make the available water go just as far as possible in crop production will still be the leading problem of Nevada agriculture.

The irrigation experiments undertaken by Dean C. S. Knight on the farm of the University of Nevada are intended to discover the stages of growth of alfalfa, wheat, and potatoes in which irrigation is most essential and most beneficial and to find out likewise the number of irrigations and the quantity of water applied in each irrigation which will yield the most profitable crop. These experiments will be completed in the fiscal year 1918–1919. Similar work will then be undertaken on a cooperative basis in the principal farming regions of Nevada. Dean Knight plans to test and to extend the information obtained from his experimental plots by similar experiments upon a much larger scale under actual farming conditions in other valleys of the State. This project is planned to give answers to questions continually asked of the Experiment Station: How much water should be applied to wheat? How many irrigations? How many inches of water at one time? At what stages of growth is water most needed? Then again, where water is very limited, we get the question: "With a given, limited quantity of water available, how can I get the greatest yield of wheat or of potatoes?"

The experiments listed as Project 1 have already yielded important information because they have been largely free from errors caused by summer rains; for it is difficult, when rain occurs, to separate the effect of rain from that of irrigation. Soil moisture studies have been made in order to determine the condition of the soil when water was applied. Samples of wheat raised under various conditions have been preserved and the gluten content will be determined. This will show

the effect of variations in irrigation upon the milling quality of the wheat.

Project 2—Variety Testing and Crop Improvement. Hatch Fund. Project Leader, Dean C. S. Knight, assisted by J. B. Menardi. Begun in 1914; continuous.

New varieties of the leading farm crops grown in Nevada are constantly being brought out; and new crops are being introduced in other States and other countries. Part of the work of the Experiment Station, therefore, is to test varieties and to try new crops to determine which are best suited to Nevada conditions. On the experimental plots at Reno, Dean Knight is showing that there are strains of alfalfa which are better adapted to Nevada than those ordinarily grown. His tests indicate likewise that there are a number of other sorts which are decidedly inferior to the ordinary Nevada alfalfa. This is true likewise with wheat, potatoes, barley, oats, and other important crops.

Ensilage Tests—The shortness of the growing season in valleys so high as the leading agricultural valleys in Nevada, coupled with the cool nights due to the clearness of the air, give conditions which limit the use of corn for ensilage. The Experiment Station is therefore planning to test a number of other crops which promise to produce good ensilage. Small tracts have been planted with the Russian sunflower, Sudan grass, and other promising crops, and in the course of the coming winter feeding tests on a small scale will be made to show the quality of ensilage prepared from these crops.

Project 3—Anthrax Serum. Hatch Fund. Project Leader, Dr. W. B. Mack, assisted by Dr. Edward Records. Begun in 1916; terminated in 1916.

Anthrax has been a source of loss in the Nevada livestock industry for a great many years. Owing to the low price of range cattle, combined with the infection and reinfection of grazing lands, the anthrax problem in Nevada has become a matter of great importance. The bacteria which cause anthrax live in the soil. Once the soil of a pasture becomes infected, the disease will appear year after year in animals placed upon this pasture. The purpose of this project was to determine whether the double-inoculation method of Pasteur could be replaced under range conditions by the single-treatment method worked out by Sobernheim.

In Pasteur's method the animals are inoculated with a small quantity of a culture of bacteria grown at an abnormally high temperature, thus depriving the bacteria of their usual virulence. Twelve days later they are again inoculated with a stronger virus. They are thus protected against infection. Under range conditions the difficulty with this method is that the animals have to be handled twice. This is naturally a difficult matter. The expense of handling is considerable, and the effect of driving the animals unnecessarily is decidedly bad. The method of Sobernheim consists of an injection of a serum prepared from the blood of horses which have been made immune to anthrax. At the same time a vaccine consisting of a small quantity of moderately active anthrax bacteria is injected. The advantage of this method is that only a single treatment is required and the animals are immediately made immune, while, in the method of Pasteur, after the first vaccination and before the second the cattle are more susceptible to

anthrax than before. Plainly, the advantages of the second method are of considerable importance; since it is inadvisable to drive range cattle to the vaccinating station twice, and since on infected pastures there is a probability of increased loss from anthrax after the first vaccination.

Work was begun on this project in 1916 in quarters especially provided for these studies. The project terminated successfully in the first quarter of the fiscal year 1917. The horses and burros which were used for the production of the serum yielded a very considerable quantity of unusually potent serum. This was demonstrated by standard tests upon small experimental animals.

It is probable that this method of preventing anthrax will be used more widely than any other in the future in Nevada.

Project 4—Chicken Cholera. Hatch Fund. Project Leader, Dr. W. B. Mack, assisted by Dr. Edward Records. Begun in 1914; terminated in December, 1916.

Since March, 1904, chicken cholera has been a subject of study in the Nevada Experiment Station. This project was outlined in the beginning because it was considered very desirable to develop the chicken industry in Nevada. There has been a strong tendency in past years to raise little else than sheep and cattle on the ranges, and hay with which to feed them in the valleys. With the growth of towns and cities of considerable size there has come to be a good local market for eggs and poultry in Nevada. This is supplied in part by eggs and dressed poultry shipped in from California; but the local supply of fowls and strictly fresh eggs has never been equal to the demand. It is therefore within the province of the Experiment Station to study the problems of the poultry industry, and thus to aid in its further development.

Chicken cholera has been found in five widely separated districts in western Nevada. The standard advice generally given to poultry owners in whose flocks the disease has appeared is to separate the sick from the well, isolate the sick birds, disinfect pens and yards, and keep everything scrupulously clean. These excellent measures of general hygiene have proven to be not practical in epidemics of chicken cholera. The disease is not checked by such measures, which are laborious and expensive and which under actual conditions are often out of the question. Dr. Mack, therefore, undertook a study of methods of putting a stop to chicken cholera by making the birds immune to the disease. Bacterins were prepared consisting of suspensions of dead-fowl cholera bacteria. Actual tests with thousands of birds showed that these bacterins put a prompt stop to outbreaks of fowl cholera.

Where the fowls are artificially inoculated in the laboratory, the bacterins do not protect; but field experiments have made it clear that under normal conditions the resistance of chickens can be raised by inoculation up to a point where they are immune to natural exposure.

The field test, of course, is a practical test; since it represents the condition under which infection normally occurs. For this reason this project has given ample grounds for the conclusion that, if bacterins prepared from fowls in a flock dying from fowl cholera are administered promptly, an outbreak of the disease may be ended promptly and with relatively small expense.

Project 5—Insect Injuries to Alfalfa. Hatch Fund. Project Leader, S. B. Doten. Begun in 1916; continuous.

From time to time in past years alfalfa in Nevada has been seriously injured by grasshopers, cutworms, and other insects. As far as is now known the alfalfa weevil has not yet appeared in the State, although there has been every opportunity for its introduction from Utah.

In the fiscal year 1916–1917 very few reports were received of any form of insect injury to alfalfa. This was particularly fortunate because of the fact that the supply of hay held in reserve was almost exhausted during the unusually severe winter. From time to time as insect problems present themselves this project will be active, and the Experiment Station is particularly anxious to receive reports upon insect injuries to alfalfa at the earliest possible moment.

Figure 1—A typical summer sheep camp on the range.

Project 6—Poisonous Range Plants. Hatch Fund. Project Leader, C. E. Fleming. Begun in 1916; continuous.

From the beginning of the work of the Nevada Experiment Station attention has been called to this problem by stockmen. An attempt has been made to solve the problem by studying the poisonous plants of the range from a chemical and botanical standpoint. The chemist can often determine definitely what chemical compounds are found in the plant at various stages of growth. The botanist can classify and describe the poisonous plants and study their structure and habits. All this information, although useful, is incomplete; for the primary question is really the question of methods of preventing livestock poisoning.

There is little probability of finding an antidote which can be administered to a herd of sheep in which several hundred head may be poisoned at one time; but it is extremely important to find out how to keep the sheep from being poisoned. The United States Forest Service has already shown that certain poisonous plants grow in such local

clumps that they can readily and very profitably be uprooted and destroyed. A careful study of the conditions under which poisoning actually occurs indicates that there are methods of handling sheep and cattle on the range which will reduce losses very greatly. For instance, if a drive must be made across a notoriously poisonous plant area it is a good plan to feed sheep heavily on alfalfa hay before driving them across. Under these conditions they will not eat enough of the poisonous plants to be injured.

Again, if sheep are bunched and driven hard through country where poisonous plants are abundant, they will eat every plant they can reach as they are hurried along and many of them will be poisoned. The same sheep, grazing slowly and at their ease, can be herded through the same area without loss.

It is Mr. Fleming's purpose in this project to study practical, common-sense methods of handling live stock under actual range conditions which will greatly reduce losses due to poisonous plants. A good deal of progress has already been made; and in the near future the Station plans to publish for the use of stockmen all information now available.

Project 7—Reestablishment of Native Range Forage Plants. Hatch Fund.

Project 8—Relative Importance of Native Range Forage Plants. Hatch Fund.

Project 9—Introduction of Foreign Range Forage Plants. Hatch Fund.

Project 10—Carrying Capacity of the Range. Hatch Fund. Project Leader, C. E. Fleming. Begun in 1916; continuous.

In the early years of the Nevada Station, Professor Fred H. Hillman, Head of the Department of Botany in the University of Nevada, collected and studied a number of the most important Nevada range grasses and had begun to study their relation to the livestock industry of the State when, in the year 1899, he resigned to take up important work in the Department of Agriculture. Later, between the years 1904 and 1914, Dr. P. B. Kennedy, his successor, made admirable studies of the leading range forest plants of Nevada and eastern California. The work of Messrs. Hillman and Kennedy thus laid an excellent foundation for future work upon these projects.

Mr. Fleming plans to study range plants not individually but as groups of plants which make up the forage of the range. It is not enough to point out to stockmen which plants are most important. It is of greater significance to study the conditions under which these plants grow, thrive, and reproduce themselves while in use as food for sheep and cattle.

The economic conditions governing the sheep and cattle industries in Nevada are leading steadily toward the destruction of vast areas of range and toward a lasting injury to Nevada's leading agricultural industries. Mr. Fleming has already covered on horseback hundreds of miles of Nevada range, finding regions where the native forage plants have so far disappeared that only here and there in clumps of sagebrush can remnants of the original vegetation be found.

Every year the Nevada Experiment Station is called upon for infor-

mation concerning grasses and plants which can be sown profitably upon denuded ranges. We have no such information. There is no source of supply from which seeds of this kind may be purchased. If the overgrazed ranges of Nevada are ever to be restored to their original productiveness, it must be done by methods of range management

Figure 2—A typical summer grazing range. The sheep are bedded down in an aspen area during the heat of the day.

Figure 3—A badly depleted piece of sheep range due to excessive use of the same area as a bed ground

which will permit the native forage to reproduce itself and again to occupy the land. There is no other course which gives any promise of success; and it appears quite unlikely that ranges which have been almost ruined will ever be restored unless they are taken in charge by the Federal Government and made into grazing reserves. It is hard to

imagine any other condition under which permanent systems of management and control will be introduced and the grazing lands restored to their original carrying capacity. From the beginning, then, in this line of work, the Nevada Experiment Station will find itself hampered by unfortunate economic conditions which threaten heavy loss to the sheep and cattle industries in Nevada.

Project 11—Relative Feeding Value of Crops of Alfalfa. Hatch Fund. Project Leader, Dr. C. A. Jacobson. Begun in 1916; to terminate in 1918.

From early in the history of the State of Nevada there has been a belief that there is a great difference in feeding value between first-crop and second-crop alfalfa hay. In some of the valleys it is stated that the first crop is far better for milk production than the second crop. In others the statement is made that first-crop hay is coarse and full of weeds, and that second-crop hay should always be fed in preference to the first crop for milking purposes.

The first crop comes on slowly through a growing period extending from early spring until the latter part of June. In the fields this gives pepper-grass and other weeds a chance to grow to their full height. The second crop comes on very rapidly during the heat of summer, smothering the weeds by this rapid growth, and maturing within a period not much longer than six weeks. It may readily be true, therefore, that there is a distinct difference in feeding value, and it may even be true that first-crop hay from certain valleys may have a higher feeding value than hay of the second crop, while in other valleys conditions may be reversed. Dr. Jacobson has therefore undertaken to find out by carefully planned chemical tests whether there is any definite chemical difference in the composition of the two crops.

Analyses were made of third-crop hay from regions where a third crop is cut, together with tests of alfalfa grown in the southern part of Nevada where as high as six crops are cut annually. It is planned to compare the results of chemical analyses with actual feeding tests made under controlled conditions in the Department of Dairying in the School of Agriculture. This project will be completed in the fiscal year 1917–1918.

ADAMS FUND PROJECTS

Project 12—Snow Studies and Snow Surveying. Adams Fund. Project Leader, Dr. J. E. Church, Jr., assisted by S. P. Fergusson. Begun in 1906; concluded in 1917.

This group of studies terminated with the close of the present fiscal year; and, while the Department of Meteorology will in the future be included in the Experiment Station, no further allotments of funds are now planned for the support of the present projects. The history of the frost and snow studies conducted by the Nevada Experiment Station is of interest.

Frost Forecasting:

In 1906 Dr. Church thought it possible to forecast frosts for valley regions from adjacent mountain peaks sooner and more accurately than they could be predicted from stations in the valley. This led to the establishment of a meteorological station equipped with elaborate automatic recording instruments upon Mount Rose (10,800 feet), a peak of the Sierra Nevada near Reno. The theory upon which this

project was based was that changes in weather conditions take place in the upper air sooner than at the lower levels. However, a considerable mass of published data then existing, simultaneous mountain and valley records, gave ample evidence in favor of the opposite conclusion. That

Figure 4—Excellent location for snow sampling. Protected by forest timber.

is, the records made upon Mount Washington and at Burlington, Vt.; upon Pike's Peak and at Colorado Springs, Colo.; upon Fuji, Japan, and at Yamanaka; all pointed to the same conclusion—that tempera-

ture changes in the valley and upon adjacent mountain summits normally occur at the same time.

On Mount Rose all the earliest instrumental records pointed to the same conclusion—that the temperature of the air rises and falls on the summit at the same time that it does in the valley, unless clouds lying between summit and valley or local winds varying in direction cause changes to occur sooner at one point than at the other.

Moreover, from the beginning the question of the relation of this project to Nevada agriculture was a difficult one. Nevada is a hay and livestock region; and, while the development of apple orchards might be assisted by more accurate methods of predicting spring frosts, the fact that changes occur simultaneously on the summit and in the valley gives no hope whatever of more accurate methods of frost prediction than those in general use.

After the Mount Rose record had been continued for many years with simultaneous records made by similar instruments at Truckee, Cal., and at Fallon, Nevada, it was so evident that the conclusion based on the earlier published records was entirely valid that from an administrative standpoint it became essential to terminate the work upon this project. S. P. Fergusson was therefore called upon to summarize the data and the project was ended by the publication of Bulletin No. 85, June, 1915, Nevada Agricultural Experiment Station.

Forest and Snow Studies:

Early in the history of the Mount Rose Weather Observatory, Dr. Church began making observations upon the degree to which the pine and fir forests of the Sierra Nevada Mountains protect the snow, both during the period of its accumulation and during the melting period. These studies became a project in the Department of Meteorology in 1906, under the title, "The Relation of Forests to the Conservation of Snow." It was the purpose of this project to determine in a general way the extent and manner in which the accumulation and melting of snow may be influenced by the presence or absence of pine and fir timber. In these studies Dr. Church has aimed to determine in the Tahoe basin the degree to which mountain forests aid in the accumulation of snow and retard its melting.

Like the project on frost forecasting from mountain tops, this project has always lacked a clear relationship to Nevada agriculture, although not for the same reasons. The former project was based upon a mistaken theory, while the latter, although sound in theory, could have no direct effect upon agricultural practise. Practically all farming in Nevada is dependent upon melting snow for its existence; and any information which might be obtained upon the protection afforded by forests to snow would seem of value to Nevada farmers and to farmers throughout the arid West.

Still, it is evident that such information would affect forest practise rather than farm practise, since the whole region under study from the time when the project was founded has been a part of the United States Forest Reserve. It is evident, therefore, that there was no threat of injury to Nevada agriculture from destructive methods of lumbering in the Tahoe region; and plainly, since nearly all the watershed forests of the Sierra Nevada are included in forest reserves, it is evident that this question of the degree of protection given by forests

to snow is not an agricultural problem. It is a minor problem in forestry lying wholly within the jurisdiction of the United States Forest Service. That service is fully aware of the danger of destructive lumbering and is pledged to the policy of protecting watershed forests. This project, therefore, has little direct connection with western agriculture; it has, moreover, been largely complete since 1910; and, as there seems to be no valid reason for its further continuance, it is not planned to support it any longer from the funds of the Agricultural Experiment Station.

Figure 5—Location for sampling protected by surrounding mountains. Mount Rose sampler in use.

Snow Surveying and Run-Off Forecasting:

In order to give a definite agricultural connection to the work of the Department of Meteorology, it seemed best in the years between 1913 and 1917 to develop as the major work of this department a study of methods of snow surveying by means of the Mount Rose snow sampler, devised by Messrs. Church and Fergusson for use in connection with the timber and snow studies. It was the purpose of this project to determine whether it is possible to make in the early spring accurate forecasts of the amount of water which will be available for storage during the melting period and for irrigation late in the summer. It is clear that while these studies originated in a project entitled "Timber

and Snow," they constitute a wholly different line of work and should be considered a distinct project.

The agricultural connection is evident from the fact that important changes in farming practise may be based upon early and accurate forecasts of water to be available. Thus, a warning given early in the spring that there will be little or no water for the late irrigations might cause the planting of wheat instead of potatoes for that year; since it would be possible to grow a crop of wheat in a season when water shortage in late summer would make it out of the question to mature a crop of potatoes. Grain may be planted instead of alfalfa that year, since the latter would be apt to dry up and die late in the summer.

Throughout the arid West water is being used more and more economically over a steadily increasing acreage, and it is becoming more important to know long in advance how much water will be available for the late irrigations. For these reasons in the fiscal year 1913–1914 snow surveying and run-off forecasting were made the major work of the Department of Meteorology and continued to be the principal feature of that department until the present year. Elaborate equipment and ample assistance were provided in order to make it possible to carry the experimental work in snow surveying rapidly to a valid conclusion. Interest in the results of this project shown in other States and in other countries where agriculture is dependent upon the melting snow for irrigation indicate the importance of this change of plan in the Department of Meteorology.

The data obtained in the last four years taken in connection with earlier work upon this project have rendered this line of study relatively complete, and in the coming fiscal year the method of snow surveying will be presented in full detail in bulletin form. There is every prospect that the method will be adopted in other States and other countries, and that it will be of great value toward the solution of problems of water storage, power production, and irrigation.

The termination of the frost studies, the completion of studies of timber and snow, and the perfection of Dr. Church's method of snow surveying make it desirable at the present time to terminate active work upon this group of projects and to make no further allotments from the station funds to the Department of Meteorology in the absence of problems in Nevada agriculture for whose solution meteorological science is required.

Project 13—Chemistry of Nitrogen Fixation. Adams Fund. Project Leader, Dr. C. A. Jacobson. Begun in 1909, carried on by Dr. Jacobson in European laboratories September, 1911, to January, 1913. Project then active in Nevada to June 30, 1917, but not included in active list of 1917–1918.

When this project was founded in 1909 it was not based upon any problem in the agriculture of the State of Nevada, but its purpose was to throw some light upon the problem of nitrogen fixation in plants by stating in chemical terms the process of fixation which takes place in the alfalfa plant. It was assumed from the beginning that the alfalfa plant obtains its nitrogen by a symbiotic relationship with certain bacteria present in nodules upon the roots of the plant. From the outset, however, Dr. Jacobson studied the nitrogenous compounds pres-

ent in alfalfa hay, extracting them by steeping the hay in water, alcohol, or other solvents.

In the present fiscal year a very careful study of the history of this project made it evident that there are good reasons why it should no longer be continued upon the active list of the Nevada Experiment Station. The work of Greaves, Stewart, and Hirst of Utah, page 293, Journal of Agricultural Research, Vol. IX, No. 9, makes it apparent that the alfalfa plant obtains the bulk of its nitrogen through its deep-feeding root system, much as do other plants, and that nitrogen fixation through a relationship with associated bacteria is only incidental. Moreover, it is evident that the study of nitrogenous compounds found in alfalfa hay can contribute only indirectly to the solution of the fixation problem.

In order to state the nature of this process in chemical terms it would seem advisable if not essential, as a preliminary, to study cultures of nodule bacteria grown under laboratory conditions and to determine whether they fix nitrogen under such conditions, and, if so, in what form. It is essential, likewise, to study nitrogenous compounds found in the living plant rather than in the hay, since the latter has been exposed to the sun after cutting and has gone through a process of curing and drying which can hardly fail to destroy or to modify the nitrogenous compounds found in the living plant.

On the whole, therefore, since the project promises no contribution to any of the actual problems of Nevada agriculture, and since under any circumstances it would be necessary to lay down a different working plan and to develop the work along quite different lines, it seems that during the war it will be best to discontinue the project; and it is not planned to include it on the active list in the coming fiscal year. Practically all data obtained from this project have been published by Dr. Jacobson in contributions to chemical journals made from time to time as units of the work were completed. This method of publication makes it unnecessary to issue any portion of the work in bulletin form.

Project 14—Plant Poisons. Adams Fund. Project Leader, Dr. C. A. Jacobson. Begun in 1909; continuous.

This project is closely connected with Project 6, "The Study of Poisonous Range Plants." It is desirable to isolate the active poisonous matter from the range plants known to be poisonous or suspected of possessing poisonous properties. After the poison has been separated and its chemical nature determined, it then becomes readily possible to find in what portion of the plant it occurs and at what season. This knowledge may easily have a direct influence upon methods of handling live stock on the range. Certain plants which are poisonous at one stage of growth may be harmless at another; to avoid poisoning it may be necessary merely to graze such plants at the proper season. It will be necessary, however, to develop studies of the effect of poisoning upon experimental animals under laboratory conditions in the Department of Veterinary Science, in order to find whether any poisonous plant under test is equally poisonous to sheep, cattle, and horses. It has been found in some instances that plants poisonous to cattle are harmless to sheep.

As a part of the University's study of poisonous range plants this project will make information regarding them gained from range

observations more accurate and more thoroughly reliable. It is planned that in the near future three departments of the Station will give a considerable amount of time to the study of poisonous range plants. The Department of Range Management will study the habits of these plants in the field, the localities in which they grow, conditions favorable to their reproduction and spread, and the extent and character of losses which they cause. This department will likewise study methods of handling sheep and cattle on the range which will tend to prevent poisoning; with methods of destroying certain plants which can be locally exterminated at small expense.

The Department of Veterinary Science will determine the classes of stock which are poisoned, the symptoms of poisoning, and the amount of poisonous material required to produce death; and in cooperation with the Department of Chemistry will work upon methods of treatment or possible antidotes. The Department of Chemistry will determine the chemical nature of the poisons and the part of the plant in which the poison is found, the stages of growth in which the plant is dangerous and the season of the year when the poison is most to be dreaded. Upon the work of these three departments will be based recommendations and warnings to western stockmen. This line of work will for several years be one of the most important activities of the Nevada Experiment Station.

Project 15—Equine Anemia (Swamp Fever). Adams Fund. Project Leader, Dr. W. B. Mack, assisted by Dr. Edward Records, 1915–1917. Begun in 1908; continuous.

For a great many years there has existed in Nevada, as elsewhere in the United States and other countries, an obscure disease of horses in which the animal becomes emaciated and bloodless, dying perhaps after several years or within a few months or weeks. The indefinite character of the disease and the fact that it is produced experimentally only with great difficulty made the subject a particularly hard one to study. The project was founded in September, 1908, in response to a demand for assistance from farmers and stock raisers in eastern Nevada. Very careful work was done for several years until in 1915 the disease almost disappeared and has not yet reappeared to an extent which gives an opportunity for further study.

During the progress of this study Dr. Mack has kept in close touch with workers in other States and in Europe who are studying the same disorder. No one has found it possible to discover the cause of the disease. Papers published by Dr. Mack have been accepted in Europe as standard contributions and have added to the existing knowledge of the subject. The most important contribution to agriculture made in connection with this problem by the whole group of workers in America and Europe, including Dr. Mack, is that under some conditions the disease may be spread by infected drinking water, and that its spread may be checked by promptly killing and burning diseased animals.

To veterinary science Project 14 has contributed painstaking and accurate descriptions of equine anemia, descriptions which separate it clearly from similar diseased conditions due to other causes. The work done by Dr. Mack has found wide acceptance among other workers on the same subject in America and Europe. The papers published at the

Nevada Experiment Station are quoted as authoritative additions to the literature.

Project 16—Hemorrhagic Disease in Cattle. Adams Fund. Project Leader, Dr. W. B. Mack, assisted by Dr. Edward Records. Begun in 1914; still in progress.

In western Nevada and southern California on elevated valley pastures, especially where water is apt to gather and stand, a hemorrhagic disease in cattle, closely resembling anthrax, has been recognized for several years. Frandsen reports the finding of a single case of disease in cattle where the symptoms resembled anthrax, "but all indications pointed to hemorrhagic septicemia"(Annual Report, Nevada Station, 1904). The primary purpose of this project has been to find out the nature of this disease; that is, to separate it clearly from anthrax and to determine whether or not it is caused by the comparatively well-known hemorrhagic-septicemia organism.

Thus far, after prolonged and careful study, it has been found impossible to determine the cause of the disease with certainty. Positive diagnoses of hemorrhagic septicemia have been made in a number of cases. From the majority of cases, however, the hemorrhagic-septicemia bacteria have not been isolated and up to the present time the diagnosis remains in doubt. Oddly enough, very promising methods of prevention and cure have been devised by Dr. Mack and his assistant, Dr. Records, prior to a complete diagnosis of the disease. From the standpoint of general hygiene it is clearly important to drain wet meadow lands, since the disease occurs most commonly on badly drained and wet lands.

Project 17—Hog-Cholera Serum Purification. Adams Fund. Project Leader, Dr. W. B. Mack, assisted by Dr. Edward Records. Begun in 1915; to terminate in 1918.

The standard method of preventing hog cholera consists in the administration of serum prepared from the blood of hogs which have been rendered highly immune to this disease. The method of treatment is highly successful and is widely applied. Wherever it has been used, however, certain difficulties have arisen. In the first place, the dose required is very large, and the amount of inert material, such as dead blood-cells, fibrin, etc., which is introduced, may cause considerable local irritation. Moreover, it has not been found possible wholly to free hog-cholera serum from contaminating bacteria even when the serum is prepared under the best conditions.

The administration of hog-cholera serum may therefore be followed by local abscesses which are often serious and sometimes destructive. In this project it is Dr. Mack's purpose to precipitate the active principle of hog-cholera serum and to isolate this active principle from all contaminating bacteria and dirt. If this proves to be possible, the bad after-effects of the standard serum treatment will be done away with; and it will be possible greatly to reduce the dosage.

Sufficient progress has been made already to show the feasibility of separating the protective properties of hog-cholera serum in a highly concentrated form. There is a strong probability that a product may be prepared free from bacteria or other contaminating matter. The process of preparation has not yet been perfected and work will be in

progress for another year. At the close of the fiscal year 1917 the success of this project seems to depend upon the possibility of devising suitable methods for a final filtration of the serum by which it may be freed completely from bacteria.

Project 18—Contagious Epithelioma in Chickens. Adams Fund. Project Leader, Dr. W. B. Mack, assisted by Dr. Edward Records. Studied under Hatch Fund, 1914 to 1916; continued under Adams Fund, 1916 to 1917.

Contagious epithelioma is a disease of chickens or perhaps a group of diseases known to poultrymen by a number of common names, among them chicken-pox, diphtheria, roup, canker, etc. When the disease appears in a flock of chickens it is quite apt to sweep through the entire flock, destroying large numbers, or even nearly all.

The disease is common in fowls the world over. The most characteristic symptoms are scabby sores which break out on the combs and wattles and around the eyes of the infected birds. Puffy swellings may close the eyes entirely. The throat is frequently attacked and death often occurs because the larynx is obstructed by false membranes.

Study of this disease was begun originally under the Hatch Fund. The purpose of the project was then to determine whether it would be feasible to prepare a vaccine from sick birds in infected flocks and by means of this vaccine to put a stop to the spread of the disease. Vaccines were prepared by crushing scabs from the combs, cheesy masses from the interior of the head, and pieces of membrane from the throat, and grinding them up in distilled water with a little salt. The material was then filtered through cotton and was heated for one hour. The virulence of the material thus prepared was so reduced by heating that small doses could be safely injected into healthy birds.

Crude vaccines prepared in this way proved very successful in promptly checking the spread of the disease in flocks where it had broken out. Beside this, the vaccine showed a genuine curative quality. Attempts were made to filter and to purify the vaccine, but purification greatly reduced its effectiveness.

Thus, this early work under the Hatch Fund showed that information is lacking upon a great many matters connected with the growth of the virus which causes the disease. In order to study contagious epithelioma from a scientific standpoint, therefore, the project was outlined under the Adams Fund, covering a number of topics upon which further information is needed. This work will be continued for several years as material is found for further study. Thus far the project has been of great value to the poultry industry in Nevada and elsewhere. Between four and five thousand birds have been treated by vaccination, and invariably the disease has been checked.

The growing importance of the local poultry industry has been mentioned above. Contagious epithelioma has helped to prevent its further development. Thus, the discovery of a reliable method of checking this disorder has made it possible for Drs. Mack and Records to give exceedingly valuable assistance toward the development of chicken-raising in Nevada.

Project 19—Biting Flies of Cattle. Adams Fund. Project Leaders, J. L. Webb, U. S. Department of Agriculture, and S. B. Doten, Nevada Experiment Station. Begun in August, 1916; probable termination, 1919.

For several years past complaints have been received at the Nevada Station of the injury done by biting flies which attack cattle on mountain pastures. The statement has been made repeatedly that cattle are so annoyed by these flies that during the height of the summer on the best of pasturage they do not put on flesh as they should and a considerable financial loss results.

It was therefore thought best to outline as a station project the study of the biting flies affecting cattle in western Nevada and adjacent portions of eastern California. Because of the fact that a part of these studies would necessarily be made outside of this State a cooperative arrangement was made with the Department of Agriculture, Bureau of Entomology, by which the work would be shared equally by the Nevada Experiment Station and the Federal Bureau. In August, 1916, Messrs. J. L. Webb and F. C. Bishopp of the United States Department of Agriculture spent some time visiting the fly-infested regions in Nevada and California to find a locality where this line of study could be conducted to advantage. Antelope Valley, lying partly in Nevada and partly in California, was chosen as a particularly desirable site.

In the fiscal year 1916–1917 a working plan was laid down in detail, and careful field studies were begun in April, 1917. An insectary was constructed at Topaz, California, the most convenient postoffice for the Antelope Valley region. With the assistance of Mr. Rufus Ogilvie, Student Assistant in Entomology, Nevada Experiment Station, Mr. Webb is now carrying on active field and laboratory work. There is every prospect that these studies will have to be continued for a number of years before the life-histories of these biting flies have been worked out in sufficient detail to permit recommendations for methods of control.

Project 20—White Sage Studies. Adams Fund. Project Leader, C. E. Fleming. Begun in October, 1916; continuous.

This project was originally proposed by Dr. P. B. Kennedy of the Department of Agronomy, University of California, whose studies of native Nevada forage plants have been mentioned in connection with Project 8. Dr. Kennedy early recognized the fact that there is no other plant in the native forage of the State whose importance equals that of the white sage (*Eurotia lanata*) as winter feed. From the earliest history of the State the sheepmen and cattlemen have regarded the white sage pastures as the best winter range to be found in Nevada. The white sage, however, like the rest of the native forage plants, has been greatly abused under unrestricted grazing.

It is a very common thing nowadays to have stockmen ask: "What are we going to do when the white sage is gone?" They take it for granted that the white sage will be practically exterminated. In many ways this will be a serious matter for the livestock industry, and to

some stock owners it will prove to be a positive disaster. It is quite evident that the Nevada Experiment Station can do no more at present on this project than to study in detail the habits of growth of the white sage and the conditions under which it reproduces and spreads, and the grazing conditions and methods which are particularly harmful.

It seems exceedingly probable that Mr. Fleming will be able to devise methods of range management which will permit the continuous use of the white sage ranges without harm to this exceedingly valuable forage plant. It should be clearly stated, however, that these methods can be applied only upon ranges under control. Competitive grazing means ruin, in the long run, to the white sage range and it means little else to most of the other range country in Nevada. On white sage ranges under private control it should be possible to introduce methods of grazing which will prevent further injury and will slowly restore the carrying capacity of the range.

Project 21 — Anthrax-Serum Purification. Adams Fund. Project Leader, Dr. W. B. Mack. Assisted by Dr. Edward Records. Begun in 1916; probable termination, 1919.

This project grew out of Project 3, Hatch Fund, "The Preparation of Anthrax Serum." It was shown in the former project that anthrax serum may profitably be used in immunizing range cattle against anthrax. A highly potent serum was produced, but against it could be urged some of the same objections spoken of concerning the standard hog-cholera serum.

The success attained by Drs. Mack and Records in the precipitation of the active principles of hog-cholera serum led to the application of similar methods of precipitation of anthrax serum, the object being, of course, to separate the active principles from bacteria and other contaminating material. The administration of such purified serum should prevent serum shock or sickness; the dosage would be greatly reduced and the liability of complications arising from contaminating bacteria would be nearly eliminated. Enough progress has been made in the fiscal year 1916–1917 to show that the active principle of this serum can be precipitated readily.

This project will be continued through the coming year in the hope of devising a practical method of purifying and concentrating the anthrax serum.

DEPARTMENT OF AGRONOMY

PROJECT 1—IRRIGATION EXPERIMENTS

Irrigation Experiment with Alfalfa, Potatoes, and Wheat

The object of this investigation was to determine the critical stages in the irrigation of each crop and to show at what stages of growth the plants are best able to be deprived of an application of water without causing serious injury to the crops; also to determine the amount of water required for the greatest production, and the production with small applications at different stages. With potatoes and alfalfa a comparative study was made of the plants at different stages of growth with different methods of irrigation to determine the proper stages to irrigate these crops, and the proper amount of water to use at each application for the best results. With wheat the object was to determine at which stage or stages of growth an application of water may be eliminated without greatly affecting the yield of grain, and to determine whether or not two applications of water prove as effective as three or more applications with the same amount of water used.

Alfalfa

The irrigation experiment with alfalfa included 12 plats which were separated by levees four feet wide and high enough to prevent any overflow from one plat to another. Six-inch, nine-inch, and twelve-inch applications were made at the following stages of wilting:

(1) Before plants show need of water by dark-green color of foliage.

(2) When plants show need of water by dark-green color of foliage.

(3) When plants have suffered, as indicated by dark-green color of foliage and drooping leaves.

During the season of 1916 two crops of hay were harvested on July 10 and September 27, respectively. Samples of hay from each plat with the two cuttings were selected for a determination of moisture and nitrogen content.*

Irrigation of Alfalfa

Average Results for 1915 and 1916

	No. of plat	Depth of application—Inches	Total irrigation—Inches	Total water content—Per cent	Proportion of leaves—Per cent	Yield per acre—Tons	Yield per acre-foot of water—Tons
Plants never allowed to show need of water.	2	6	63	84.2	36.3	6.33	1.22
	5	9	58	86.0	38.1	6.38	1.31
	8	12	72	81.4	37.6	7.32	1.23
Irrigated when plants show need of water by dark-green color of foliage.	3	6	42	78.6	40.1	5.70	1.64
	6	9	40	81.2	42.1	5.62	1.66
	9	12	48	77.8	39.3	6.21	1.62
Irrigated when plants show need of water by dark-green color of foliage and drooping leaves.	4	6	21	78.8	48.8	3.73	2.16
	7	9	27	77.5	43.6	4.30	1.91
	10	12	30	72.8	37.3	5.20	2.09

The results showed that with the 6-, 9-, and 12-inch applications the average total irrigation, the total water content of the plant and the yield per acre decreased, while the proportion of leaves to stems and the yield per acre-foot of water increased with the advance in the wilting stage. The average variations found were from 64 to 21

*The nitrogen content was determined by the official method used by the Bureau of Chemistry, U. S. Dept. of Agriculture.

inches in total irrigation, 83.9 to 76.4 per cent in total water content, 37.3 to 43.2 per cent in proportion of leaves to stems, 6.68 to 4.41 tons in yield per acre, and 1.29 to 2.05 tons in yield per acre-foot of water.

Although the greatest yield of 7.32 tons per acre was found with the heaviest total irrigation of 72 inches, the yield per acre-foot of water was only 1.23 tons. These results indicate that the most economical use of water would be with the 12-inch applications given between the last two stages of wilting with a total irrigation of from 30 to 48 inches, or an average of 36 inches with an average yield of 5.7 tons per acre, or 1.85 tons per acre-foot of water.

In the three stages of irrigation the 6-inch applications gave the lowest yields and the 12-inch applications the highest yields with but little variation in yield per acre-foot of water. Where the total yield per acre was greatest the yield per acre-foot of water was low and the quality of hay was inferior to that of the other plats, due to the large proportion of coarse stems to leaves. The results clearly illustrate the importance of the time of application of water, since a gradual decrease in yield is noted in the different plats with the same applications of water as the wilting stage advances before the water is applied. Alfalfa responded better than wheat and potatoes to the heavy applications of water.

Potatoes

The irrigation experiment with Burbank potatoes included nineteen plats. The potatoes were planted May 29, 1916, in rows three feet apart and about fourteen inches apart in the row. The potatoes were irrigated by means of comparatively deep furrows three feet apart. Three-inch, six-inch, and nine-inch applications of water were made at the following stages of growth:

(1) Before plants show a tendency to wilt.
(2) When plants show a tendency to wilt.
(3) When all leaves wilt down once.
(4) When all plants fail to revive at night.

The crop was harvested on October 1, 1916. Of the four rows in each plat the two outside rows were eliminated to prevent as far as possible any variation due to lateral diffusion of water from the adjoining plats. Three hills in different parts of each plat were selected for a chemical analysis of the starch content.*

Irrigation of Potatoes

Average Results for 1914, 1915, and 1916

	No. of plat	Depth of irrigation—Inches	Total irrigation—Inches	Water content—Per cent	Starch content—Per cent	Yield per acre—Pounds	Yield per acre-foot of water—Pounds
Plants never allowed to wilt	2	3	21	76.7	68.3	12,566	7,181
	6	6	28	76.4	65.4	10,367	4,443
	10	9	36	77.3	68.3	13,380	4,460
Irrigated when plants show tendency to wilt	3	3	16	78.4	64.4	14,010	10,507
	7	6	20	77.3	63.2	9,587	5,752
	11	9	27	77.2	65.2	7,875	3,500
Irrigated when all plants wilt down once	4	3	10	78.4	56.2	11,151	13,380
	8	6	14	78.5	62.4	9,611	8,238
	12	9	18	76.1	64.8	6,992	4,661
Irrigated when plants fail to revive at night	5	3	6	78.7	59.3	6,031	12,062
	9	6	8	78.4	58.8	5,798	8,697
	13	9	9	78.6	59.8	4,069	5,425

*The starch content was determined by means of the direct acid hydrolysis. See Bulletin 107, p. 58, Bureau of Chemistry, U. S. Dept. of Agriculture.

The yields of potatoes in 1915 were materially decreased by dry rot, and in 1916 by an unfavorable season. However, all plats appeared to be equally affected; thus the comparative results are about as valuable as with greater production. The results showed that with the 3-, 6-, and 9-inch applications, the average total irrigation, the starch content, and the yield per acre decreased while the yield per acre-foot of water increased with the advance in the wilting stage. The average variations found were from 28 to 8 inches of total irrigation, 67.3 to 59.3 per cent of starch, 6.05 to 2.64 tons per acre, and 2.68 to 4.36 tons per acre-foot of water.

The best average results were obtained with the 3-inch applications at the different stages of wilting, comparatively little variation being shown between 6- and 9-inch application. For the three-year period, the highest yield of 7 tons per acre was obtained with an average total irrigation of 16 inches with 3-inch applications given when the plants showed a tendency to wilt, and the yield per acre-foot of water was 5.25 tons. The next best yield of 6.69 tons per acre was secured with four 9-inch applications given before plants showed a tendency to wilt, although the yield per acre-foot of water was only 2.23 tons per acre. Where the plants wilted down before irrigation, the potatoes made a second growth which resulted in lowering their starch content. The proportion of scabby potatoes was greatly increased in those plats which received a total irrigation of 24 inches or more of water.

Wheat

The irrigation experiment with wheat included 60 plats. The plats were 22 feet wide by 165 feet long and were separated by levees 4 feet wide. Marquis wheat was used. The seed was treated for smut with a solution of formalin (one pound of formaldehyde to 40 gallons of water) and was sown April 5, 1916, with a double-disk drill, about two inches deep, using 75 pounds of seed per acre. In the irrigation of the wheat 3-inch, 5-inch, and 7-inch applications were made at the following stages of growth:

1. Five leaves;
2. Boot;
3. Bloom;
4. Milk;
5. Dough.

In this test the comparison was made of plats receiving an irrigation at each of the five stages of growth with plats in which an irrigation was omitted at each of the five stages; with plats in which irrigations were omitted at any two of the five stages of growth, and with plats that received the same amounts of water in only two applications—one before and one after heading.

The wheat plats were harvested from August 6 to August 12 with the grain binder. The plats receiving the least total irrigation, when an irrigation at the milk stage was omitted, were the first to reach maturity. Four feet of grain around the outside of each plat was eliminated to prevent as far as possible any error due to seepage from one plat to another. The wheat was threshed with a small thresher operated by a 6-horsepower gasoline engine. This machine made possible the thorough cleaning of the grain and caused practically no grain to be lost in threshing.

Irrigation of Wheat

Table Showing Increase in Yields of Seven-Inch Applications over Three-Inch Applications in Percentabe for 1914, 1915, and 1916

	Yield per acre in bushels								
	3-in. application			Average	7-in. application			Average	Average increase
	1914	1915	1916		1914	1915	1916		
One irrigation omitted at—									
Five-leaf	21.2	26.2	31.3	26.2	32.6	36.8	35.3	34.9	33.2
Boot	17.1	15.3	29.6	20.7	31.8	28.9	20.1	27.2	31.4
Bloom	19.4	14.0	24.9	19.4	24.2	26.3	31.7	27.4	41.3
Milk	27.1	28.6	29.2	28.3	26.2	28.4	37.0	30.5	7.8
Dough	29.4	21.8	32.8	28.0	32.3	25.1	34.2	30.5	8.9
Two irrigations omitted at—									
Five-leaf and boot	21.8	14.8	20.7	19.1	22.5	18.6	17.1	19.4	1.6
Five-leaf and bloom	15.9	20.7	30.9	22.5	22.9	16.9	25.9	21.9	2.7
Five-leaf and milk	22.5	25.8	33.4	27.2	19.2	31.8	43.3	30.1	10.7
Five-leaf and dough	10.1	32.4	35.7	26.1	29.8	27.2	34.6	30.5	16.9
Boot and bloom	7.8	12.8	21.0	13.9	12.6	12.5	25.6	16.9	21.6
Boot and milk	14.8	21.3	29.4	21.8	16.9	21.2	36.8	25.0	14.7
Bloom and milk	15.6	20.3	29.4	21.8	18.3	19.3	34.4	24.0	10.1
Bloom and dough	16.2	19.1	37.6	24.3	23.9	24.8	39.3	29.3	20.6
Milk and dough	20.0	28.1	37.8	28.6	25.0	30.5	34.4	30.0	4.9
No irrigations omitted	26.0	26.9	32.1	28.3	24.2	26.1	43.1	31.1	9.9

One Irrigation Omitted—The results are strongly in favor of the 7-inch applications. The average yield for the 7-inch applications was 24.5 per cent greater than that for the 3-inch applications. The highest yield of 34.9 bu. per acre was obtained when the irrigation at the five-leaf stage was omitted. When irrigations were omitted at the milk and dough stages, respectively, the same yield of 30.5 bu. per acre was secured.

The lowest yields with both 3- and 7-inch applications were found when irrigations were omitted at the boot and bloom stages, respectively.

When a 7-inch application was given at each stage of growth, or a total irrigation of 35 inches, the yield was 31.1 bu. per acre or 12.2 per cent less than where only 28 inches of water were applied and the irrigation omitted at the five-leaf stage. This was due chiefly to the greater development of root system where the first irrigation was omitted, and at the same time the plants did not suffer from lack of sufficient moisture before the irrigation at the boot stage.

Two Irrigations Omitted—Here also the results are in favor of the 7-inch applications, although not to such a great extent as where only one irrigation was omitted. The average yield for the 7-inch applications was 11.5 per cent greater than that for the 3-inch applications.

The four highest yields were obtained when irrigations were omitted at the five-leaf and dough, five-leaf and milk, milk and dough, and bloom and dough, in the order named, the greatest production being 30.5 bu. per acre, and the lowest 29.3 bu. per acre, or a difference of about 4 per cent.

The three lowest yields with the 7-inch applications averaging 19.4 bu. per acre were obtained when the irrigations were omitted at the five-leaf-and-bloom, five-leaf-and-boot, and the boot-and-bloom stages, the last yield being 16.9 bu. per acre.

The low yields with both 3-inch and 7-inch applications when irrigations at the boot and bloom stages were omitted, indicated that the

most critical stage in the irrigation of wheat was between the boot and milk stages. When irrigations were omitted at the five-leaf-and-milk and five-leaf-and-dough stages, practically no difference was noted in the yield, the average being 30.3 bu. per acre.

Irrigation of Wheat—Two Irrigations
Average Results for 1914, 1915, and 1916

Irrigation—Inches		Yield in bushels				Average yield per acre-foot of water
Before heading	After heading	1914	1915	1916	Average	
6	6	18.7	21.4	42.1	27.4	27.4
6	9	23.7	21.2	36.8	27.2	21.8
6	12	27.0	----	31.9	29.5	19.7
9	6	16.7	18.9	31.5	22.4	17.9
9	9	25.8	24.8	43.0	31.3	20.9
9	12	23.5	26.6	37.3	29.1	16.6
12	6	19.7	27.2	36.8	27.9	18.3
12	9	19.1	25.3	34.2	26.2	15.0
12	12	22.7	27.0	37.3	29.0	14.5

Where only two irrigations are possible the two 9-inch applications, one before and one after heading, gave the greatest yield of 31.3 bu. per acre or 11.5 per cent less than the highest yield when one 7-inch irrigation was omitted at the five-leaf stage, or slightly greater than when five 7-inch applications were given at each stage of growth. The 12-inch irrigation before heading provided more water than the crop utilized to the best advantage. The maximum yield was obtained with 18 inches of water. With a total irrigation of less than 18 inches the yield was considerably lower; whereas a total irrigation of 24 inches in two 12-inch applications produced a yield of 29 bu. per acre, or 8 per cent less than with the two 9-inch applications.

The yield of 27.4 bu. per acre-foot of water was greatest with the smallest total irrigation of 12 inches and least, or 14.5 bu., with the largest total irrigation of 24 inches. The most practical method used in this experiment was when the highest yield was recorded. Where only two applications were given to the crop the yields were generally lower throughout than where a greater number of applications with the same total amount of water was given, thus indicating that only in cases of water shortage is it advisable to use only two applications in preference to three or four applications, as shown in the results of this experiment where the fields of grain are generally much higher. At the same time where only two irrigations are possible, the yield of 31.3 bushels per acre indicates a very profitable crop.

Soil Moistures—Irrigation of Alfalfa, Average 1915–1916
Average Results of first four feet in depth in per cent

Soil sample staken	6-inch applications	9-inch applications	12-inch applications
Irrigated before plants show need of water—			
Before first irrigation	14.5	13.7	17.8
Before second cutting	15.9	18.8	16.4
Per cent of decrease	9.7*	37.2*	8.5
Irrigated when plants show need of water by dark-green color of foliage—			
Before first irrigation	13.4	14.9	15.3
Before second cutting	13.3	13.6	12.8
Per cent of decrease	.07	9.6	21.1
Irrigated when plants show need of water by dark-green color of foliage and drooping leaves—			
Before first irrigation	12.0	14.7	14.9
Before second cutting	11.6	11.6	9.1
Per cent of decrease	3.4	26.7	64.4

*Increase.

Alfalfa

The results show that with the 6- and 9-inch irrigations given before the plants showed need of water, the soil moisture contents before the first irrigation were less than before the second cutting by 9.7 per cent and 37.2 per cent, but with the 12-inch applications, greater by 8.5 per cent. With the 6-, 9-, and 12-inch applications given when plants showed need of water by dark-green color of foliage, the soil moisture contents before the first irrigation were greater by .07 per cent, 9.6 per cent, and 21.1 per cent, and in the last wilting stage greater by 3.4 per cent, 26.7 per cent, and 64.4 per cent, respectively. This decrease in soil moisture in the two wilting stages was very slight with 6-inch irrigations, considerably greater with 9-inch irrigations, and very much greater with 12-inch irrigations. The decrease also became greater as the wilting stage advanced.

Where the heaviest application of 72 inches of water produced the greatest yield of 7.32 tons per acre, the soil moisture content before the second cutting was 8.5 per cent greater than before the first irrigation.

Where the smallest application of 21 inches of water produced the lowest yield of 3.7 tons per acre, the soil moisture content was 3.4 per cent less than before the first irrigation. However, the yield per acre-foot of water was 2.09 tons, or 70 per cent greater than where the highest yield was secured with the greatest total irrigation.

The greatest variation was found in the last stage of wilting with the 12-inch irrigations, where the soil moisture content at the second cutting was 64.4 per cent less than before the first irrigation.

Soil Moistures—Irrigation of Potatoes, Average 1914, 1915, and 1916

Average Results of first four feet in depth in per cent

Soil samples taken	3-inch applications	6-inch applications	9-inch applications
Irrigated before plants show tendency to wilt—			
Before first irrigation	20.7	19.4	20.0
Before harvest	19.8	20.1	19.5
Per cent decrease	4.5	3.6*	2.5
Irrigated when plants show tendency to wilt—			
Before first irrigation	18.9	20.9	18.4
Before harvest	18.7	20.4	19.2
Per cent decrease	1.1	2.4	4.3*
Irrigated when leaves wilt down once—			
Before first irrigation	19.5	16.4	19.0
Before harvest	18.9	17.7	17.4
Per cent decrease	3.1	7.9*	9.1
Irrigated when plants fail to revive at night—			
Before first irrigation	19.2	18.7	18.4
Before harvest	17.5	16.6	18.8
Per cent decrease	9.7	12.6	2.1*

*Increase.

Potatoes

With the 3-inch irrigations at the different stages of wilting the soil moisture contents before harvest were slightly less than before the first irrigation. This decrease is most evident in the last stage of wilting with 9.7 per cent.

With the 6-inch applications an increase is shown in the first and third stages of wilting, while in the second and last stages the soil moisture content was greater than before the first irrigation, amounting to 12.6 per cent in the last stage of wilting.

With the 9-inch irrigations a decrease was shown in the first and third stages of wilting, amounting to 9.1 per cent in the third stage.

while in the second and the last stages of wilting the soil moisture content at harvest was slightly greater than before the first irrigation.

Where the heaviest yield of 7 tons per acre was produced with a total irrigation of 16 inches of water in 3-inch applications given when the plants first showed a tendency to wilt, the soil moisture content before harvest was only 1.1 per cent less than before the first irrigations. However, the yield per acre-foot of water was 5.25 tons.

Where the lowest yield of 2.03 tons per acre was produced with one 9-inch application at the last wilting stage, the soil moisture content at harvest was 2.1 per cent greater than before the first irrigation. However, the yield per acre-foot of water was only 2.71 tons, or 92.6 per cent less than that of the highest yield with 16 inches of total irrigation.

No uniform variations occurred in soil moisture content with potatoes as were found with alfalfa in the various stages of wilting and with different depths of applications of water, with the exception of the slight decrease at harvest with the 3-inch irrigations at the different stages of wilting.

Soil Moisture—Irrigation of Wheat, Average 1914, 1915, and 1916

Average Results of first four feet in depth in per cent

Soil samples taken	One irrigation omitted			Two irrigations omitted		
	Irrigation omitted	3-inch application	7-inch application	Irrigation omitted	3-inch application	7-inch application
Before first irrigation	None	21.3	19.2	Five-leaf	21.6	20.1
Before fourth irrigation	None	15.8	17.4	and	17.6	18.0
Before harvest	None	17.8	16.9	boot	18.5	19.6
Average		17.8	17.7		19.2	19.3
Before first irrigation	Five-	20.4	20.0	Five-leaf	21.7	17.5
Before fourth irrigation	leaf	16.6	19.6	and	15.7	15.1
Before harvest	stage	16.1	20.6	bloom	18.7	19.8
Average		17.7	20.1		18.7	17.5
Before first irrigation	Boot	20.3	20.4	Five-leaf	19.7	18.4
Before fourth irrigation	stage	16.1	19.0	and	15.0	17.2
Before harvest		16.6	21.0	milk	15.9	18.6
Average		17.7	20.1		16.7	18.0
Before first irrigation	Bloom	18.6	20.2	Five-leaf	19.2	18.4
Before fourth irrigation	stage	11.9	17.2	and	17.6	17.5
Before harvest		16.0	22.3	dough	17.7	18.4
Average		15.5	19.9		18.2	18.1
Before first irrigation	Milk	19.0	17.9	Boot	19.9	21.0
Before fourth irrigation	stage	16.1	18.6	and	12.4	15.8
Before harvest		17.4	18.9	bloom	19.3	21.0
Average		17.5	18.5		17.2	19.3
Before first irrigation	Dough	18.9	19.5	Boot	17.2	17.5
Before fourth irrigation	stage	15.6	19.6	and	14.8	16.1
Before harvest		13.0	17.4	milk	16.6	16.2
Average		15.8	18.9		16.2	16.6
Before first irrigation				Bloom	17.6	17.0
Before fourth irrigation				and	13.8	15.7
Before harvest				milk	15.8	18.6
Average					15.7	17.1
Before first irrigation				Bloom	20.9	18.4
Before fourth irrigation				and	14.3	17.2
Before harvest				dough	18.0	19.9
Average					17.7	18.5
Before first irrigation				Milk	18.5	17.4
Before fourth irrigation				and	14.3	17.7
Before harvest				dough	13.8	16.4
Average					15.5	17.1

Table Comparing Soil Moisture Content Before First Irrigation and Before the Irrigation at the Milk Stage, with 3-inch and 7-inch Applications.

Average Decrease before Irrigation at Milk Stage in Per Cent for 1914, 1915, and 1916

One irrigation omitted			Two irrigations omitted		
Irrigation omitted	3-inch application	7-inch application	Irrigation omitted	3-inch application	7-inch application
None	34.8	10.3	Five-leaf and boot	22.7	11.7
Five-leaf	22.9	2.0	Five-leaf and bloom	38.2	15.9
Boot stage	26.0	7.3	Five-leaf and milk	31.3	7.0
Bloom stage	56.3	17.4	Five-leaf and dough	9.1	5.1
Milk stage	18.0	3.7*	Boot and bloom	60.5	32.9
Dough stage	21.1	.5*	Boot and milk	16.2	8.7
			Bloom and milk	20.3	8.3
			Bloom and dough	46.1	7.0
			Milk and dough	15.3	1.6*

*Increase.

Comparison of Soil Moisture Content before First Irrigation and before Irrigation at the Milk Stage

One Irrigation Omitted—The soil moisture contents before the irrigation at the milk stage were less than before the first irrigation, except with omissions of 7-inch applications at the milk and dough stages when slight increases of 3.7 per cent and .5 per cent, respectively, were found.

The greatest decrease of 56.3 per cent with 3-inch applications, and 17.4 per cent with 7-inch applications occurred where the irrigation at the bloom stage was omitted. The yields per acre were 80 per cent and 27.4 per cent less than the highest production of 34.9 bu. per acre with one 7-inch irrigation omitted at the five-leaf stage.

The smallest decrease of 18 per cent with 3-inch applications was with an irrigation omitted at the milk stage, whereas with 7-inch irrigations an increase of 3.7 per cent occurred.

Little variation in soil moisture content was found with both 3-inch and 7-inch applications where irrigations were omitted at the five-leaf milk and dough stages. In these plats the yields per acre varied from 26.3 to 28.3 bushels with 3-inch applications and from 30.5 to 34.9 bushels with 7-inch applications.

The average decrease in the soil moisture content with 3-inch applications was 28.9 per cent, while with 7-inch applications it was only 4.5 per cent.

Two Irrigations Omitted—The soil moisture contents before the irrigation at the milk stage were less than before the first irrigation, except where two 7-inch irrigations were omitted at the milk and dough stages when a slight increase of 1.6 per cent occurred.

The greatest decrease of 60.5 per cent with 3-inch applications, and 32.9 per cent with 7-inch applications, occurred where two irrigations were omitted at the boot and bloom stages. The yields per acre were 151 per cent and 129 per cent less than the highest production with one 7-inch irrigation omitted at the five-leaf stage.

In the four plats where one of the irrigations omitted was at the bloom stage, the average decrease in soil moisture content was 41.3 per cent with 3-inch applications and 16 per cent with 7-inch applications. The average yields per acre were 69.4 per cent and 51.7 per cent less than the highest production of 34.9 per acre.

The smallest decrease occurred when two irrigations were omitted

at the five-leaf-and-dough and the milk-and-dough stages, with an average of 12.2 per cent for 3-inch and 1.8 per cent for 7-inch applications. The yields per acre were 27.8 per cent and 16.3 per cent less than the highest production of 34.9 bu. per acre.

Where two irrigations were omitted at the five-leaf-and-boot, five-leaf-and-milk, and boot-and-milk stages, the decrease in soil moisture content varied from 16.2 per cent to 31.3 per cent with 3-inch, and from 7 per cent to 11.7 per cent with 7-inch applications. The average yields per acre were 53.7 per cent less with 3-inch and 40.7 per cent less with 7-inch applications than the highest production of 34.9 bu. per acre.

The average decrease in the soil moisture content with 3-inch applications was 28.9 per cent, while with 7-inch applications it was only 10.6 per cent.

Table Comparing Soil Moisture Content before First Irrigation and at Harvest with 3-inch and 7-inch Applications

Average Decrease at Harvest in Per Cent for 1914, 1915, and 1916

One irrigation omitted			Two irrigations omitted		
Irrigation omitted	3-inch application	7-inch application	Irrigation omitted	3-inch application	7-inch application
None	19.6	13.6	5-leaf and boot	16.8	2.5
5-leaf	26.7	3.0*	5-leaf and bloom	16.0	13.2*
Boot stage	22.3	2.9*	5-leaf and milk	23.9	1.1*
Bloom stage	16.2	10.3*	5-leaf and dough	8.5	0
Milk stage	9.1	5.5*	Boot and bloom	3.1	0
Dough stage	45.4	12.2*	Boot and milk	3.6	8
			Bloom and milk	11.4	9.4
			Bloom and dough	16.1	7.5*
			Milk and dough	19.5	6.1

*Increase.

Comparing Soil Moisture Content before First Irrigation and at Harvest

One Irrigation Omitted—The soil moisture contents at harvest were less than before the first irrigation with 3-inch applications, but greater with 7-inch applications, except where an irrigation was omitted at the dough stage, when a decrease of 12.2 per cent occurred.

The greatest decrease of 45.4 per cent with 3-inch and 12.2 per cent with 7-inch applications occurred where an irrigation at the dough stage was omitted. The yields per acre were 24.6 per cent and 14.4 per cent less than the highest yield of 34.9 bu. per acre with one 7-inch irrigation omitted at the five-leaf stage.

The smallest decrease of 9.1 per cent with 3-inch applications occurred with an irrigation omitted at the milk stage, when the yield per acre was 23.3 per cent less than the highest yield. With 7-inch irrigations the greatest increase in soil moisture content at harvest occurred with an irrigation omitted at the bloom stage, where the yield per acre was 27.4 per cent less than the highest yield.

With 3-inch applications where an irrigation was omitted at the dough, five-leaf, boot, and bloom stages, the decrease in soil moisture content at harvest was 45.4 per cent, 26.7 per cent, 22.3 per cent, and 16.2 per cent, while the corresponding yields per acre were 28.0, 26.2, 20.7, and 19.4 bushels, respectively.

These results indicate that in the above stages of irrigation in the order named, as the decrease in soil moisture content at harvest becomes greater, a comparative increase in yield per acre occurs.

With 7-inch applications when an irrigation was omitted at the five-leaf, boot, and milk stages, an average increase of 3.8 per cent occurred in soil moisture content at harvest, whereas with an irrigation omitted at the bloom stage, the increase was 10.3 per cent, but the yield per acre was 13.6 per cent less than the average of the three plats, the first of which produced the highest yield in the experiment of 34.9 bu. per acre with one 7-inch application omitted at the five-leaf stage.

The average decrease in soil moisture content with 3-inch applications was 23.9 per cent, but with 7-inch applications an average increase of 1.5 per cent occurred.

The variations in soil moisture content at harvest in relation to yield per acre were not as uniform as those before the irrigation at the milk stage.

Two Irrigations Omitted—The soil moisture contents at harvest were less than before the first irrigation, except where two 7-inch irrigations were omitted at the five-leaf-and-bloom, milk-and-dough, and five-leaf-and-milk stages, where corresponding increases of 13.2 per cent, 7.5 per cent, and 1.1 per cent, respectively, occurred.

With 3-inch applications the greatest decrease of 23.9 per cent in soil moisture at harvest occurred when two irrigations were omitted at the five-leaf-and-milk stages, and the yield per acre was 27.2 bu. With the next greatest decrease of 19.5 per cent with two 3-inch irrigations omitted at the milk-and-dough stages, the yield was 28.6 bu. per acre, which was the highest yield with two 3-inch irrigations omitted.

The smallest decrease of 3.1 per cent in soil moisture at harvest with 3-inch applications occurred when two irrigations were omitted at the boot and bloom stages, when the yield was 13.9 bu. per acre, or 105 per cent less than the highest yield of 28.6 bu. with two 3-inch applications omitted at the milk and dough stages.

With two 3-inch irrigations omitted at the five-leaf and boot stages, the decrease in soil moisture at harvest was 16.8 per cent, and the yield per acre of 19.1 was next to the lowest yield of 13.9 bu. recorded above.

With two 7-inch applications omitted at the various stages of growth, no uniform variations occurred in soil moisture content in relation to the yeld per acre, as was the case with the 3-inch applications.

The greatest decreases at harvest, 48 per cent and 9.4 per cent, were found with two 7-inch applications omitted at the boot-and-milk and bloom-and-milk stages, where the yield of 21.8 bu. per acre was the same for both plats.

The greatest increase in soil moisture at harvest of 7.5 per cent and 13.2 per cent occurred when two 7-inch applications were omitted at the bloom-and-dough and five-leaf-and-bloom stages, where the corresponding yields were 24.3 and 22.5 bu. per acre, respectively.

Two Consecutive Irrigations Omitted—Where 3-inch and 7-inch irrigations were omitted at two consecutive stages of growth, a decrease was found in soil moisture content at harvest, except with two 7-inch irrigations omitted at the boot and bloom stages in which the soil moisture content was the same as before the first irrigation.

The decreases in soil moisture content at harvest with 3-inch irrigations omitted at the milk and dough, bloom and milk, five-leaf and boot, and boot and bloom, were 19.5 per cent, 11.9 per cent, 16.8 per cent and 3.1 per cent, with corresponding yields of 28.6, 21.8, 19.1, and 13.9

bu. per acre, while with 7-inch applications, the decreases in soil moistures were 6.1 per cent, 9.4 per cent, 2.5 per cent, and .0 per cent with corresponding yields of 30.0, 24.0, 19.4, and 16.9 bu. per acre.

When 3-inch and 7-inch irrigations were omitted at the boot and bloom stages, the decrease in soil moisture content at harvest was the smallest as compared with the lowest yields per acre.

The greatest decrease in soil moisture content at harvest occurred with 3-inch applications omitted at the milk and dough stages, accompanied by the highest yield per acre. But with 7-inch applications, where irrigations were omitted at the bloom and milk stages, although the decrease was only slightly less than with irrigations omitted at the milk and dough stages, the highest yield of 30.0 bu. per acre was obtained.

Generally, with two consecutive irrigations omitted, a high yield was accompanied by a considerable decrease in soil moisture content at harvest, and vice versa.

The average decrease in soil moisture at harvest where two irrigations were omitted was 13.3 per cent with 3-inch, and .5 per cent with 7-inch applications.

Soil Moistures—Irrigation of Wheat, Two Irrigations, One before and One after Heading. Average 1914, 1915, and 1916

Average Results of first four feet in depth in per cent

Soil samples taken	Irrigation—Inches		Soil moistures			
	Before heading	After heading	1914	1915	1916	Average
Before first irrigation	6	6	19.8	18.1	18.5	18.8
Before second irrigation			17.3	13.1	17.0	15.8
Before harvest			18.3	15.7	17.1	17.0
Average			18.5	15.6	17.5	17.2
Before first irrigation	6	9	18.9	19.8	18.2	19.0
Before second irrigation			15.2	16.3	15.6	15.7
Before harvest			18.2	13.3	16.8	16.1
Average			17.4	16.4	16.9	16.9
Before first irrigation	6	12	15.5	22.1	18.8	18.8
Before second irrigation			17.7	16.2	16.6	16.8
Before harvest			17.1	14.6	19.1	16.9
Average			16.8	17.6	18.2	17.5
Before first irrigation	9	6	12.8	20.1	18.1	17.0
Before second irrigation			16.7	14.7	15.6	15.7
Before harvest			15.8	14.8	12.5	14.4
Average			15.1	16.5	15.4	15.7
Before first irrigation	9	9	18.5	20.8	18.9	19.4
Before second irrigation			16.6	14.3	16.2	15.7
Before harvest			16.3	14.6	14.1	15.0
Average			17.1	16.6	16.4	16.7
Before first irrigation	9	12	17.8	19.8	17.3	18.3
Before second irrigation			15.6	13.1	16.9	15.2
Before harvest			16.3	14.8	16.0	15.7
Average			16.6	15.9	16.7	16.4
Before first irrigation	12	6	20.7	21.7	18.7	20.4
Before second irrigation			17.9	15.0	17.3	16.7
Before harvest			15.3	16.6	13.8	15.2
Average			18.0	17.8	16.6	17.4
Before first irrigation	12	9	19.1	20.6	18.5	19.4
Before second irrigation			17.8	16.5	17.8	17.4
Before harvest			14.8	15.1	15.0	15.0
Average			17.2	17.4	17.1	17.3
Before first irrigation	12	12	19.1	19.4	20.0	19.5
Before second irrigation			17.7	16.5	18.8	17.7
Before harvest			15.7	17.8	15.2	16.2
Average			17.5	17.9	18.0	17.8

Soil Moistures—Irrigation of Wheat, Two Irrigations, One before and One after Heading

Average Decrease in Soil Moisture Content before Second Irrigation and at Harvest in Per Cent for 1914, 1915, and 1916

Irrigation—Inches		Decrease of soil moisture before second irrigation	Decrease of soil moisture at harvesting	Yield per acre—Bushels	Yield per acre-foot of water—Bushels
Before heading	After heading				
6	6	19.0	10.6	27.4	27.4
9	6	8.3	18.0	22.4	19.9
12	6	22.1	34.2	27.9	18.3
6	9	21.0	18.0	27.2	21.8
9	9	23.4	29.3	31.3	20.9
12	9	11.6	29.3	26.2	15.0
6	12	11.9	11.2	29.5	19.7
9	12	20.4	16.5	29.1	16.6
12	12	10.2	20.4	29.0	14.5

The greatest decrease of 23.4 per cent in soil moisture content before the second irrigation occurred was found with a 9-inch irrigation before and after heading, accompanied by the highest yield of 31.3 bu. per acre; while the smallest decrease of 8.3 per cent was found with a 9-inch irrigation before and a 6-inch irrigation after heading, accompanied by the lowest yield of 22.4 bu. per acre.

The greatest decrease of 34.2 per cent in soil moisture content at harvest was found with a 12-inch irrigation before heading and a 6-inch irrigation after heading, the yield being 27.9 bu. per acre.

The smallest decrease at harvest occurred with a 6-inch irrigation before and after heading, accompanied by a yield of 27.4 bu. per acre, and the highest yield of 27.4 bu. per acre-foot of water.

Increasing the depth of application before heading caused a greater decrease in per cent of soil moisture at harvest and a corresponding decrease in yield per acre-foot of water. This variation in depth of application after heading was not as uniform, since with 9-inch irrigations before heading, the yield per acre-foot of water was slightly greater with the 9-inch than with the 6-inch application after heading.

Monthly Precipitation Record, 1916*

Month	1914 Actual inches	1915 Actual inches	1916 Actual inches	Average inches 1914-1916	Average for past 28 years
January	5.46	0.55	6.76	4.26	2.02
February	0.86	2.59	0.59	1.35	1.20
March	Trace	0.16	0.33	0.16	0.83
April	0.70	0.33	0.11	0.38	0.46
May	0.11	0.52	Trace	0.21	0.73
June	0.29	0.00	0.11	0.13	0.28
July	Trace	0.04	Trace	0.01	0.36
August	0.38	Trace	0.04	0.14	0.31
September	0.05	0.06	0.35	0.15	0.28
October	0.16	Trace	1.13	0.43	0.34
November	Trace	0.28	0.05	0.11	0.68
December	0.70	1.09	0.97	0.92	1.07
Totals	8.71	5.62	10.44	8.25	8.56

*Information secured from the U. S. Weather Bureau, Reno, Nevada.

These results are especially interesting from the fact that during no one month of the growing season throughout the three-year period was sufficient rainfall received to affect the soil moisture content; that is, the small amount of precipitation at any one time was subject to evaporation within the few hours which followed. The greatest

monthly precipitation of .7 inches during this period was received in April, 1914, and most of this came before the first irrigation. The results of these experiments are, therefore, based entirely on water applied by irrigation.

PROJECT 2—VARIETY TESTING AND CROP IMPROVEMENT

These experiments included row tests and also plat tests of several important varieties of wheat, oats, barley, corn, field peas and beans, millets, potato and field beets, the object being to determine the varieties of these crops which show special adaptation to the local conditions by their hardiness and yielding capacity, and to improve these varieties by selection. By testing out these varieties in various parts of the State where the altitude and climatic conditions are different, it will be possible to determine the highest producing varieties of cereals and forage crops for all agricultural districts of the State.

Cereals

The experiment with varieties of wheat, oats, and barley included 24 varieties of wheat, 28 of oats, and 26 of barley. Each variety was represented by one row 100 feet long. The seed was planted March 27, 1916, about one and one-half inches deep in rows one foot apart. The results of the fifteen highest producing varieties were as follows:

RESULTS WITH WHEAT

Variety	Yield per acre of grain—Pounds			
	1914	1915	1916	Average
Galgalos Fife C. I. 2398		4,492	3,471	3,982
White Club	3,294	3,096	3,856	3,482
Defiance		3,023	3,857	3,435
Blue Stem	3,318	2,855	3,848	3,340
New Zealand	3,096	3,043	3,697	3,279
Colorado No. 50	2,730	3,625	3,452	3,269
Glyndon No. 692		2,274	3,935	3,105
Marquis	2,808	3,505	2,979	3,097
Chul	3,222	3,145	2,879	3,082
Minnesota No. 163		2,692	3,365	3,029
Fextes C. I. No. 1596		2,534	3,304	2,919
Minnesota Fife	2,100	3,643	2,978	2,907
White Australian	816	3,299	4,052	2,722
Kubanka		2,210	3,194	2,702
Stanley White	2,724	2,667	2,554	2,648

In this experiment Galgalos Fife was the highest producer for the years 1915 and 1916, yielding 66.4 bushels per acre. The next four highest producers varied in yield from 54.7 to 58.0 bushels per acre.

RESULTS WITH OATS

Early Mountain No. 2 C. I. 656		2,185	3,042	2,614
Early Mountain (Ida.)		2,041	2,187	2,114
Black American C. I. 549		1,844	1,937	1,891
Banner C. I. 751		1,922	1,853	1,888
White Danish		2,011	1,308	1,660
Siberian C. I. 741		2,054	1,222	1,638
Ont. Agr. College No. 72		1,847	1,055	1,451
Big Four	813	1,895	1,614	1,441
Danish	1,124	1,678	1,494	1,432
Siberian (Nev.)	788	2,064	1,441	1,431
Garton No. 572	663	2,223	1,340	1,409
Wisconsin Ped. No. 1	1,060	1,950	1,161	1,390
Swedish Select C. I. No. 134		1,741	1,014	1,378
Kherson	1,425	1,658	994	1,359
Colorado Black	640	1,975	1,412	1,342

These results showed a marked increase in the production of the

Early Mountain variety over the previous year, the yield being 95 bushels per acre for 1916. The average production for this variety for the two periods was 81.75 bushels per acre. This was the only variety which was not seriously affected by shattering of the seed, due to blasting of the panicles before the plants had matured. With most of these varieties over one-half of the grain had shattered before the plants were ready for harvest.

RESULTS WITH BARLEY

Variety	Yield per acre of grain—Pounds			
	1914	1915	1916	Average
New Zealand	----------	2,740	4,917	3,829
Blue Ribbon (Mont.)	3,040	3,443	4,025	3,503
Wash. Brewing	----------	3,125	3,823	3,474
C. I. 679 "France"	1,469	3,260	4,924	3,218
White Smyrna	2,395	2,522	4,667	3,195
Princess	----------	2,012	4,352	3,182
California Feed	2,367	2,814	3,975	3,052
Trebi C. I. 936	----------	2,197	3,886	3,042
Chevalier	2,720	2,660	3,625	3,002
Hanna	1,618	3,340	3,991	2,983
Moravian	3,086	2,502	3,294	2,961
Heils Hanna No. 682	3,023	1,550	4,166	2,913
Oregon No. 19785	1,465	2,734	4,314	2,838
Poda C. I. 652	1,123	3,141	4,063	2,776
White Moravian	3,315	1,561	3,432	2,769

In this test the New Zealand variety showed the highest average yield for the two-year period of 80 bushels per acre, while the Montana Blue Ribbon had an average production for the three-year period of 73 bushels per acre. The results favored the two-rowed varieties.

Forage Crops (Including Root Crops)

RESULTS WITH CORN GROWN FOR ENSILAGE

Variety	Yield per acre of fodder—Pounds				
	1913	1914	1915	1916	Average
Improved Leaming	25,795	19,513	18,709	26,264	22,570
Sweepstakes	----------	----------	17,177	26,732	21,955
Colorado Yellow Dent	----------	----------	15,317	24,570	19,944
Disco 90-Day Seed Corn	----------	----------	----------	19,746	19,746
Pride of Minnesota	21,835	17,450	13,132	24,571	19,247
Swadley's Field Corn	----------	----------	13,705	24,037	18,871
Sure Crop	21,615	16,706	14,802	21,552	18,669
Huron Dent	22,071	15,649	14,115	22,535	18,593
Minnesota No. 13	22,550	16,550	10,835	24,194	18,532
Pride of the North	21,560	12,343	15,109	20,619	17,408
Wisconsin Yellow Dent	18,562	16,281	11,811	21,614	17,067

In this experiment each variety was represented by four rows 165 feet long and 3 feet apart. The seed was planted with a hand corn-planter about 3 inches deep. Furrows were made between the rows for irrigation of the crop. During the four-year period the improved Leaming variety was the highest producer with 11.3 tons per acre. In no year did any variety mature grain, but in occasional favorite seasons certain types produced profitable crops of forage, which provided a very palatable satisfactory food for cattle and sheep when placed in a silo and fed in connection with alfalfa. In 1916 a killing frost occurred on September 10 which stopped the growth of all varieties while the grain was still in the milk stage, and on the following two days the crop was harvested.

Forage Crop for Seed Production

Variety	Yield per acre of seed—Pounds			
	1914	1915	1916	Average
Sudan grass	....	1,099	1,912	1,506
Field pea, Kaiser	....	1,198	2,135	1,667
Field pea, Amorita	....	973	2,069	1,521
Field pea, Salo	....	901	2,066	1,484
Field pea, Green Canada	....	869	1,778	1,324
Field pea, Blackeye Marrowfat	450	900	2,347	1,232
Colorado Stock	563	1,180	1,774	1,172
Marrowfat	160	752	2,502	1,138
Charleston No. 12887	301	834	1,953	1,029
White Marrowfat	450	798	1,838	1,023
White Colorado	339	875	1,611	942
White Canada	450	706	1,582	913

In this test each variety was represented by one row 100 feet long. The rows were two feet apart with the exception of the Sudan grass, in which the rows were 30 inches apart. These results show a great variation in yield from year to year, and, even though excellent yields were produced with certain types in 1916, it is evident that unless the climatic conditions are favorable successful results cannot be assured.

Forage Crops for Hay Production

RESULTS WITH FIELD PEAS

Variety	Yield per acre of forage—Pounds			
	1914	1915	1916	Average
Sudan grass	....	2,656	7,586	5,121
Green Canada	5,278	2,864	4,423	4,188
White Canada	4,800	2,595	4,370	3,922
Colorado Stock	3,738	3,487	4,068	3,764
Blackeye Marrowfat	4,860	1,897	4,128	3,628
White Marrowfat	3,270	2,005	3,402	2,892
Green Canada (Elko Dry Farm)	....	3,170	3,980	3,575
Gold Vine (Elko Dry Farm)	....	2,410	4,407	3,409
White Canada (Elko Dry Farm)	....	2,654	3,669	3,162
Bangalia (Elko Dry Farm)	....	2,114	2,972	2,543

In this experiment the seed was planted April 16, 1916, in rows 165 feet long and 30 inches apart, four rows representing each variety with the exception of Sudan grass which was represented by two rows each 50 feet in length. In 1916, Sudan grass produced 3.79 tons per acre, while the average for the two years was 2.5 tons per acre. Green Canada field pea showed the heaviest production of forage from this crop, or 2.09 tons per acre.

RESULTS WITH MILLETS

Variety	Yield per acre of forage—Pounds			
	1914	1915	1916	Average
Siberian	6,595	3,547	6,149	5,430
Hog (Elko Dry Farm)	....	4,251	6,168	5,210
Kurch (Elko Dry Farm)	....	4,076	6,227	5,147
Sudan grass	....	2,656	7,586	5,121
Common (Elko Dry Farm)	....	4,627	5,135	4,881
Colorado Golden	5,546	2,287	4,581	4,121
Early Fortune	4,693	2,389	4,907	3,996
Hungarian (Elko Dry Farm)	....	2,649	4,744	3,697

In this experiment the seed was planted May 25, 1916, in rows 100 feet long and 30 inches apart, two rows representing each variety. In the 1916 results, all millet varieties were surpassed by Sudan grass in production of forage, while for the two- and three-year averages the Siberian, Hog, and Kurch showed an increased production. The planting of Sudan grass in rows 30 inches apart instead of 36 inches was undoubtedly partly responsible for the remarkable increase in yield.

RESULTS WITH POTATOES

Variety	Yield per acre—Pounds				
	1913	1914	1915	1916	Average
Great Divide	21,700	13,025	6,169	7,750	12,161
Burbank	16,520	10,027	8,096	5,931	10,204
Peerless	18,460	6,152	6,438	6,516	9,392
Early Russet	19,220	3,562	7,827	4,579	8,797
Early Red	12,160	4,222	5,979	3,954	6,579
Netted Gem (Nev.)				6,440	6,440

The potatoes were planted May 23, 1916, in rows 265 feet long and 3 feet apart. Great Divide and Burbank varieties showed the highest average yields for the four-year period with 12,161 and 10,204 pounds per acre, respectively. These two varieties have been grown in Nevada for many years and indicate the value of well-selected home-grown seed over that introduced from other States.

RESULTS WITH BEET VARIETIES

Variety	Yield per acre—Pounds			
	1914	1915	1916	Average
Our Ideal mangels	16,616	17,669	60,096	31,460
Mammoth Long Red mangels	14,994	13,155	54,856	27,668
Sugar-beet (Nevada seed)		12,465	41,770	27,118
Golden Tankard mangels	17,172	13,886	48,751	26,603
Giant Feeding mangels	12,929	20,975	43,065	25,656
Sugar-beet (Foreign seed)	16,275	14,505	41,595	24,125

The beet varieties were planted on April 6, 1916. The seed was sown at the rate of 20 pounds per acre about one inch deep in rows 100 feet long and 2 feet apart. In this test the aim was to compare the values of the sugar-beets, half sugar-beets, and mangel, as a supplementary feed in fattening cattle, sheep, and swine. This table shows that the mangel produced a much higher yield of roots, but, due to the high content of carbonaceous food in the sugar-beet, the latter had a food value much greater than the mangel. The sugar content varied from 19.5 per cent in the sugar-beet to 4.5 per cent in the mangel. These results indicate that the sugar-beet is the most valuable root crop for feeding purposes under Nevada conditions.

RESULTS OF CEREAL VARIETIES IN PLATS

Variety	Yield per acre—Pounds	Yield per acre—Bushels
Wheat—		
White Club	3,331	55.5
Bluestem	2,736	45.6
Minnesota No. 163	2,495	41.6
Oats—		
Great Dakota	1,125	35.2
Wisconsin Ped. No. 1	864	27.0
Kherson	504	16.0
Barley—		
Chevalier	2,858	59.5
Moravian	2,720	56.7

These varieties of cereals were among the highest producers during the two preceding seasons in the row variety test.

The White Club wheat and Great Dakota oats were outstanding high yielders as compared with the other varieties under experiment. However, with the two varieties of barley tested, the yields showed but little variation. Both of the barleys were of the two-rowed type.

Cooperative Variety Tests—Variety tests of wheat and barley were conducted in 1916 on the farms of Tom Dolf and W. H. Williams of Fallon, in cooperation with F. B. Headley, Superintendent of the United States Experiment Farm at Fallon. The following table includes the results for 1916 and the average yields for 1915 and 1916 in bushels per acre:

Wheat				Barley			
Variety	1915	1916	Average	Variety	1915	1916	Average
Little Club	45.5	52.3	48.9	Coast	42.5	36.8	39.6
Rieti	42.7	48.5	45.6	Kents	29.9	39.9	34.9
Dicklow	41.6	42.3	42.0	Haunchen	33.0	30.3	31.6
Marquis	39.0	42.9	41.0	Chevalier	......	31.3	31.3
Defiance	38.5	42.1	40.3	Svanhals	29.9	29.3	29.6
Sonora	37.3	41.0	39.2	Nepal*	25.4	27.0	26.2
Bluestem	40.5	37.4	39.0				
Gherka	35.0	36.2	35.6				

*This is a hulless barley with a standard weight per bushel of 60 pounds, but for comparison by actual weight with the other varieties 48 pounds per bushel was used.

Little Club was the highest producer of the wheat varieties with an average yield of 48.9 bu. per acre for the two years. Coast, or what is commonly known as California Feed barley, was the highest yielding variety of barley with 39.6 bu. per acre. The yield of 2,934 pounds of Little Club wheat was 54.2 per cent greater than the yield of 1,903 pounds of the highest yielding barley.

DEPARTMENT OF VETERINARY SCIENCE AND BACTERIOLOGY

We began the year with the following projects, the first two of which have been completed and terminated:

Hatch Fund:
- Project 3—Anthrax Serum.
- Project 4—Chicken Cholera.

Adams Fund:
- Project 15—Equine Anemia.
- Project 16—Hemorrhagic Disease in Cattle.
- Project 17—Hog-Cholera Serum Purification.
- Project 18—Contagious Epithelioma in Chickens.

A new project, entitled Project 21—"Anthrax-Serum Purification," has been undertaken under the Adams Fund.

A statement of the inception, progress, and present status of the various projects follows.

PROJECT 3—ANTHRAX SERUM

When this project was proposed in 1914 and later undertaken, we were confronted with a very serious situation with respect to anthrax, and felt keenly the need of an agent with which to combat it in addition to vaccine. The situation was the worst it had been for several years, the loss the heaviest. A large number of cattle and other domestic animals died, and a former State Veterinarian became infected and died.

Previous to 1915 there was no provision for state control of the acute infectious diseases of live stock in the State, nor had anything comparable to the present service been attempted. There were even no authorized facilities for precise diagnosis and advice. The necessity had not yet become sufficiently apparent to develop the requisite legislation, which usually follows public necessity or demand.

In the anthrax outbreaks of 1914 our assistance was sought. The laboratory examinations resulted in a diagnosis of anthrax in several localities. Previous to that time the identity of the trouble was a subject of controversy and doubt. The diagnoses were largely speculative, varying according to individual information and opinion. After an accurate diagnosis of anthrax was established advice logically followed. Owners were advised to remove their herds from infected to clean ground and to vaccinate by the double method of Pasteur. In several instances the removal of cattle to clean ground was impossible, no such places being available. Vaccination increases the susceptibility during a certain period while immunity is being established. During this period the loss may be increased temporarily, although ultimately the cattle treated are enabled to resist infection.

Difficulties then arose over vaccinating twice, from ten to fourteen days apart. To round up and vaccinate cattle is laborious; and range cattle particularly suffer from too much driving and handling, especially in summer. We insisted, however, upon the use of the

double method, and most owners who vaccinated that season followed our advice. Those who used a single vaccination had less favorable results than those who employed the double method.

Anthrax is usually acute in cattle, but that summer we saw many animals with a less acute type which lived long enough to afford reasonable opportunity for treatment had one been available. Antianthrax serum was at the time being produced and used with some success in Europe, but the United States was slow in undertaking its production and no serum was available.

We were very much dissatisfied with the weapons available in the existing situation and felt keenly the need of more adequate equipment. We believed that a potent antianthrax serum could be prepared, with which immunity could be immediately conferred and which, in addition, might be successfully used in the treatment of subacute cases. Could that hope be realized, cattle which were not yet infected could be immunized by the simultaneous administration of serum and strong virus, and safely left to graze upon infected land. Cattle which were already infected could be treated with large doses of the serum alone and many saved which otherwise must perish.

With these objects in view, September 1, 1914, we outlined a project for the preparation of antianthrax serum and to ascertain its cost and practicability under Nevada conditions. Two burros, contributed for the purpose by an interested private livestock corporation, were immunized, and kept upon an infected ranch. They were carried to the point where they could withstand the injection of large doses of fully virulent cultures of the anthrax organism and were shipped to Reno. For want of suitable quarters for the work and delay in constructing them, work on this project was postponed until about January 1, 1916. This delay was particularly unfortunate, but appeared unavoidable.

Three horses were purchased and the hyperimmunization of the five animals undertaken. One horse died during immunization. The remaining four animals were successfully treated. The burros produced serum which tested satisfactorily; that from the horses possessed a very high degree of potency, far in excess of established European standards. We were fortunate in securing potent serum from all our animals, as it is claimed that only about 20 per cent will respond to hyperimmunization by the production of potent serum. One horse was bled all that he could reasonably be expected to stand, and was kept for future work. The other animals were bled to death. The work under this project was terminated November 1, 1916.

Meantime the anthrax situation changed materially. The State Veterinary Control Service was organized and active control of acute infectious diseases undertaken. In 1915, 1916, and 1917 practically all the cattle destined to graze upon infected lands were vaccinated. The usual annual losses from anthrax have practically disappeared, and unless infected districts yet unknown to us are reported there will be no further loss of any consequence. It was our intention to test the efficacy of the serum we prepared in the work of the State Veterinary Control Service, but we have found no cases upon which to test it. A single case, diagnosed clinically by a practising veterinarian as anthrax, was recently treated with it and promptly recovered. Blood specimens from this animal were submitted for precise diagnosis; but

were negative for anthrax, so we have no satisfactory evidence that the animal treated was infected. There the matter must rest unless we encounter an outbreak in which we can test the serum. We might use this serum for simultaneous immunization, but desire to test it therapeutically when the opportunity presents.

Eichorn* of the United States Bureau of Animal Industry, working along similar lines, has produced potent antianthrax serum, and used it successfully both as an immunizing and and curative agent. Two or three commercial laboratories have recently placed similar serum upon the market at a reasonable price. Thus the obstacles encountered delayed this work in Nevada until the objects sought were achieved by others. Nevertheless, there is now available what we hoped for—a potent antianthrax serum by the use of which immediate immunity can be conferred and the lives of many infected animals saved.

In considering practicable methods for the control of anthrax in infected localities, of the various methods available two appear feasible—the double vaccination of Pasteur, and the serum-vaccine method. The latter must not be confounded with single vaccination, which consists of the injection of a single dose of attenuated virus, too weak to confer immunity. In the serum-vaccine method the injection of a dose of serum is immediately followed by one of virus stronger than could safely be given except for the protection afforded by the serum. The advantage of the serum-vaccine method lies in the immediate immunity conferred and the necessity for handling the cattle but once. Its single disadvantage is that the materials used cost more than the double vaccine. On the other hand, while the latter costs less than serum-vaccine, it requires about three weeks to confer immunity, during which time the cattle are more susceptible than if untreated, and requires two injections. Owners and control officials must weigh these considerations against each other in selecting the method to be employed in any particular case. In the State Veterinary Control Service work we have used both. The respective results appear about as above stated. Our cattle owners appear to favor the serum-vaccine, and that method will undoubtedly eventually replace the double method.

We do not contemplate the preparation of antianthrax serum for distribution, as there are satisfactory sera upon the market at reasonable prices.

PROJECT 4—CHICKEN CHOLERA

The results of our fowl-cholera studies were published as Agricultural Experiment Station Bulletin No. 85, December, 1916, under the title "The Use of Bacterins in the Control of Fowl Cholera."

An outbreak of fowl cholera came to our attention in March, 1914. Subsequently, it was found in five widely separated districts in western Nevada. There were no commercially prepared immunizing agents available for the control of fowl cholera and no satisfactory method for suppressing outbreaks. The separation of the sick from the well, their isolation, the disinfection of infected premises and similar measures are laborious, expensive, always difficult, and many times impossible to apply; and even under rigid official control have proven almost uniformly inadequate and unsatisfactory. It, therefore, appeared to

*Eichorn: Vaccination Experiments Against Anthrax. Jour. Am. Vet. Med. Assn. N. S., Vol. I, No. 6 (1916), p. 669.

us that we should use the opportunity presented to study the possibilities of developing a practicable method for the suppression of outbreaks of fowl cholera by immunization.

In Bulletin 85 we present the results of our experiments upon 1,986 birds in fourteen infected flocks. The paper is summarized as follows:

The existence of fowl cholera in Nevada has been demonstrated.

The outbreaks were serious and ultimately destructive, but somewhat less acute than those described as typical.

The Nevada strains of *Bact. avisepticum* possessed a comparatively low degree of virulence for chickens in laboratory tests. No strain behaved uniformly as to the time required to kill when inoculated into chickens; some birds failed to succumb to inoculation. The virulence for chickens could not be maintained by frequent passages through either rabbits or chickens; and no strain could be depended upon to kill by oral administration.

One rabbit was successfully immunized by the subcutaneous administration of bacterin. This method failed to immunize chickens against subsequent subcutaneous or intramuscular inoculation, although no more than three injections of bacterin were tried.

The use of bacterins in infected flocks produced sufficient resistance to check promptly outbreaks of fowl cholera in fifteen out of sixteen lots of fowls in fourteen flocks, although one flock required three treatments. It failed in another flock in spite of three vaccinations.

The results of field trials with bacterins as an agent for checking and controlling outbreaks of fowl cholera indicate that it is a practicable satisfactory method.

In fourteen out of sixteen lots of fowls treated, one or two injections of bacterin satisfactorily controlled the outbreak, with little or no difference in the result. In one lot there was recurrence requiring three treatments. Complete failure resulted in but one of the sixteen lots treated.

There was no apparent difference in the results whether homologous or heterologous strains of *Bact. avisepticum* were used in the preparation of bacterins. The use of stock bacterins containing several strains appears to be satisfactory, and is the logical method where a stock is to be carried for immediate use when needed.

Finally, in the last analysis, the value of a protective method must be judged by clinical rather than by experimental results.

It is difficult to produce a degree of immunity sufficient to protect animals against experimental inoculation with the virus of any of the large group of infections of which fowl cholera is one, by methods which are applicable to field conditions. The best we can hope for is to increase resistance to a point where they can resist natural exposure, which is less severe than experimental inoculation. The method described in Bulletin 85 has, since publication, been further employed in field work by the State Veterinary Control Service, with results as favorable as those published. This work is an advance in fowl-cholera control, materially strengthening our equipment.

PROJECT 15—EQUINE ANEMIA

When our study of this disease was undertaken in 1907, it was exceedingly prevalent in certain districts in eastern Nevada. The loss was heavy and there were no recoveries. It was a serious problem,

menacing the horse industry and demanding investigation. Our studies were actively conducted for several years, during which time the clinical character of the disease was well established, the tissue changes ascertained, and much valuable information acquired. We undertook to demonstrate by experimental inoculations whether or not the disease was infectious, and conducted many such experiments. The results of these experiments were more or less conflicting; so that point has not been definitely established. Treatment has never been successful.

This work has been at a standstill for two or three years for want of material, due to the natural decline of the disease.

In April, 1916, a horse was inoculated with blood collected from what appeared to be a case of equine anemia found in western Nevada, but the inoculated animal failed to develop the disease. No further material became available during 1916. We now have two or three suspicious cases under observation and are on the lookout for suitable material for a continuation of our study. If suitable cases materialize, the work will be continued along slightly different lines. The questions in point will be kept in mind, as we have no intention of abandoning the project. Meantime, however, our time is fully occupied with more pressing problems, and the plan suggested will cost very little unless opportunity presents for resuming active work.

PROJECT 16—HEMORRHAGIC DISEASE IN CATTLE

During a period of about five years, 1909 to 1914, we examined material submitted by cattle owners and practising veterinarians from a number of cattle suspected of anthrax. Several times we diagnosed that disease; but encountered a number of cases in which the history and autopsy findings rendered such a diagnosis probable, but laboratory examinations were negative. Until 1914 these cases did not assume much volume, and, with the exception of a few cases, we regarded them as probable nonspecific disorders. The few exceptions, however, gave rise to serious consideration and when, in 1914, their material importance became evident we concluded that a thorough systematic investigation must be undertaken. Arrangements were made accordingly, and for about two and a half years this has been our major problem.

The project was outlined as an inquiry to ascertain the identity of the disease by precise methods, and an attempt to devise efficient methods for its control or suppression and eventually its eradication.

We have attempted diagnosis in many and various ways. The epidemiological history, clinical aspects, and anatomical changes; the results of bacteriological examination of various tissues and organs: the experimental inoculation of various animals in considerable numbers with cultures, blood, exudate, and various tissues; agglutination and complement-fixation tests of serum; the vaccination of cattle in herds where the disease has appeared; the treatment of clinical cases with the serum of hyperimmunized horses; and the topographical and telluric conditions of the infected districts have been considered.

As a rule this disease does not occur in epidemic form, but as occasional scattering cases. In one herd of 325 cattle there were 90 cases during four months, but this is exceptional. However, in the aggregate the loss is considerable. A large percentage of the cases occur from May to January, but there are a few during the winter and early spring. It appears to be infectious, but not contagious.

Affected animals are dejected, with staring coat, distressed facial expression, swollen eyelids, tucked-up abdomen, and stand with their backs arched. Respiration is rapid, of a shallow abdominal type. Frequently the animal grunts with each inspiration or when forced to walk. There is a moderate rise in temperature, seldom above 104°F., but in some cases to about 105.8°F. The pulse is rapid and compressible. The urine is almost invariably deeply blood-stained before death. Blood is frequently passed with the feces.

The principal gross anatomical changes consist of hemorrhages and liver infarction. In typical cases the autopsy reveals extensive small hemorrhages into the subcutaneous and intermuscular connective tissues, upon the serous surfaces of the abdominal cavity and viscera, the pleura, both the pericardial and endocardial surfaces, into the intestine and the urinary tract. Unborn fetuses may show marked hemorrhages. In most cases there is extensive infarction of the liver. There is considerable exudation into the body cavities, with edematous infiltration about the lymphatic glands, many of which are swollen and hemorrhagic. The spleen may be normal, although in some instances it shows moderate engorgement. There are little or no pulmonary changes, except surface hemorrhages. There is a peculiar yellowish discoloration of the tissues; the carcass emits a characteristic odor difficult to describe.

Cultures from the blood are apt to be negative; from the liver, spleen, kidney, lymph glands, bile, urine, and exudates from fresh carcasses they are frequently so. Cultures from some organs may yield mixed growths, while others remain sterile. In carcasses sufficiently fresh to exclude the probabilities of extensive post-mortem invasion, if the cultures develop growth they usually consist of mixed species of small rod-shaped bacteria. In the examination of tissue smears, those from the liver present the most constant appearance. There are almost invariably large rod-shaped bacteria with ends slightly rounded, occurring singly, in twos and threes, staining deeply, and numerous deeply staining bodies resembling diplococci. We have never succeeded in cultivating either in artificial media.

Animals have been inoculated in considerable numbers. We have used a large number of rabbits, many guinea-pigs, several cattle, two sheep, two chickens, and a horse for this purpose. Rabbits have been carried to the autopsy field for inoculation, or have been inoculated in the laboratory with both cultures and tissue suspensions.

In the results of our inoculations there are, of course, variations, but in the main they are fairly uniform. Rabbits inoculated with cultures sometimes survive; occasionally they die and the cultures are not recovered; again, we may kill several in series and finally lose the cultures; in four instances such a series yielded *Bact. bovisepticum*. Rabbits and guinea-pigs inoculated with liver or lymph-gland emulsions usually die, the cultures from their heart blood and organs remaining sterile. Inoculations with liver suspensions can be continued in series, cultures remaining sterile, and continued sometimes through many animals. the liver tissue carrying virus. The series may result in bacteriemia, from which cultures are obtainable, or the virus may become so attenuated that it finally fails to kill. In a microscopic examination of liver smears from rabbits thus killed, the large rod-shaped bacteria above referred to are never found. The diplococci-like bodies persist throughout long series, but do not grow in cultures.

We have isolated five strains of *Bact. bovisepticum*—two in 1915, one in 1916, and two in 1917. Four were isolated from the liver, one of them in a collateral series from a lymph-gland; the other from the blood. Four strains were isolated by means of cultures; one by direct inoculation with tissues. However, with material from a large number of autopsies, we have failed to isolate this bacterium or any other which appeared responsible for the disease. The percentage of recoveries of *Bact. bovisepticum* is so small that it materially reduces the diagnostic significance of their isolation.

Agglutination and complement-fixation tests have not yet proven of diagnostic value.

We have prepared bacterial vaccines from the cultures of *Bact. bovisepticum* isolated here and used them upon 4,886 cattle. It is more difficult to estimate the result of vaccination than if the disease occurred in epidemic form. In many herds no very accurate records are kept. The identity of vaccinated cattle is sometimes lost. For these reasons no absolutely accurate data are obtainable. We can only contrast the loss with that in the same herds in former years, and have only general statements of owners as a basis for such contrasts. Furthermore, we must rely largely upon the experience and judgment of the cattle owners as to the cause of death, as in but a few cases were we able to autopsy the animals returned to us as having died. Thus far twenty-four vaccinated cattle have been reported to us as dead, an insignificant fraction of the loss in the same herds in former years.

In a dairy herd in which the disease has occurred each summer for several years, vaccinated for the first time, there were two cows which showed marked dejection, rise of temperature, and increased respiratory and pulse rate, after both the first and second injections. The owner thought that these cows had previously suffered an attack and had recovered without treatment. The diagnosis in these former attacks is based solely upon the owner's observations and experience. The temperatures of the herd were taken and two others showed a similar increase, while the remainder of the herd were normal. The temperatures were taken 18 hours, 24 hours, and 42 hours after injection. At 18 hours and 24 hours they were high in the four cases referred to; at 42 hours they had returned to normal.

It is possible that the four cases in question were previously infected and had thus become sufficiently sensitized that they reacted to the injections as stated. If so, these reactions may have some diagnostic significance. Further observations will be made upon this point.

An antihemorrhagic-septicemia serum has been prepared by the hyperimmunization of horses with cultures isolated in our work. Several strains of *Bact. bovisepticum* and *Bact. avisepticum*, closely related species, have been used in hyperimmunizing the horses. After appropriate tests for potency the serum has been used in the treatment of clinical cases occurring in cattle. The diagnoses were necessarily by clinical means, as no specific diagnostic test upon the living animal has become available. For that reason there may have been some errors, but we believe that in most cases the diagnosis was correct.

Twenty-two clinical cases have been treated with such serum. Seven have died and fifteen recovered, a percentage of recovery of 68.18. The number of cases thus treated is too small to render the results conclusive,

but they appear significant and are sufficiently encouraging to warrant continuance until a volume is reached sufficient to warrant a conclusion.

Cattle grazing upon the range, supplied with water from mountain streams or springs, are seldom affected. Those living in the wet valleys, or brought there from the range, having access to the sloughs, suffer principally. Some owners find that a transfer of cattle from wet to dry pastures ends the trouble. When returned to low ground it may be resumed. Some dairymen remove their cattle from pasture and feed hay in dry corrals if the disease appears.

Some valleys are naturally wet; others have become so through irrigation with defective drainage. Throughout the infected areas the trouble occurs in cattle feeding along sloughs or upon overflowed land. Of course, there is nothing peculiar to this disease in that respect. Lands in the conditions mentioned harbor other diseases beside the one under consideration. Wet valleys in mountainous regions are considered ideal for the occurrence of hemorrhagic septicemia.

Bacteria closely resembling those causing hemorrhagic septicemia have a wide distribution in nature, apparently leading a saprophytic existence. That those bacteria may assume pathogenesis under certain conditions is an opinion entertained by some investigators, and the adherents to that opinion are increasing in numbers. That such an organism thus exists in the swamps and sloughs of certain districts, and that the conditions referred to are frequently realized, is not an untenable theory; and, if proven, would account for the occurrence of hemorrhagic septicemia without specific introduction from outside. That specific introduction is essential in many infectious diseases is unquestionable. That there are exceptions, however, is not impossible.

Upon the foregoing facts we base a tentative diagnosis of hemorrhagic septicemia. We realize that much of the evidence is inconclusive; that other inferences might be drawn. However, there is much in the evidence to support it. The work is incomplete and must be continued until the identity of the disease is indisputably established.

From the evidence at present in hand it seems probable that drainage may ultimately solve the problem of control. Thorough drainage of these valleys is not attainable under present conditions and much of the land is unsuitable for other purposes than grazing. It appears that seasonable vaccination will increase resistance so that only the most susceptible individuals will be subject to attack, and that the prompt treatment of such cases with antihemorrhagic-septicemia serum will reduce the losses to a minimum.

PROJECT 17—HOG-CHOLERA SERUM PURIFICATION

This project was undertaken in an attempt to overcome the difficulties arising in the preparation and use of defibrinated blood in immunization against hog cholera.

By chemical precipitation we are undertaking to separate the active portion of hog-cholera serum so as to be able to discard the blood corpuscles, fragments of fibrin, albumin, contaminating bacteria, and all inert and useless material.

That the protective properties of hog-cholera serum can be precipitated with the globulins by the use of ammonium sulphate as a precipitating agent, our experiments have clearly demonstrated. In undertaking this

work it was assumed as a working hypothesis that the protective portion of the serum would accompany the pseudoglobulin fraction, as is the case with antidiphtheritic and antitetanic sera, and that the euglobulin fraction could be discarded, in which case a very material concentration could be effected.

Our experiments, however, show that both the euglobulin and pseudoglobulin fractions are potent, so that the euglobulins cannot be discarded. It, therefore, becomes necessary to utilize the entire globulin content. This will permit less concentration than would be the case if the euglobulin fraction had proven impotent, but concentration is of less importance than the other objects sought, which apparently are being realized.

Eight lots of serum have been processed and tested upon pigs by the simultaneous use of the globulins and hog-cholera virus, controlled by the use of raw serum from the same lot and virus, with proper checks. The results of these tests have been uniformly satisfactory, the globulins apparently protecting hogs against inoculation as successfully as does raw serum. Our data are beginning to assume sufficient proportions to warrant the above conclusion. At present we are somewhat hampered by the scarcity and high price of pigs, but hope to be able to secure a sufficient number to complete the necessary experiments. We contemplate the use of hog-cholera serum globulins in actual field work in the near future.

In this work numerous technical difficulties have arisen. These appear to be nearly solved with the exception of the difficulties encountered in final filtration. The globulin solutions must finally be passed through filters of the Berkefeld type in order to effect sterilization. Considerable difficulty is encountered in the filtration. Whether we will be able to overcome this entirely, so that the method we are employing may become commercially practicable, must be answered by additional experiments. Otherwise, the method appears feasible and practicable; and, when prices of chemicals and laboratory materials return to normal, the expense of the process should not be prohibitive.

PROJECT 18—CONTAGIOUS EPITHELIOMA IN CHICKENS

An unusually good opportunity was presented for the work under this project when it was undertaken in December, 1914. Contagious epithelioma had appeared in a large flock in Reno. It was severe in character, a considerable portion of the flock was already infected, the disease was spreading rapidly, and the death loss was becoming heavy. The owner was discouraged and pessimistic over the prospects. In previous outbreaks he had lost heavily and feared that his flock would be destroyed.

Certain German investigators claimed success in the suppression of outbreaks of this disease by vaccination. The Wisconsin Agricultural Experiment Station had recently tried the German experiments upon a small scale, with apparent success. This outbreak supplied the opportunity to repeat the experiments upon a commercial scale. The disease appearing in several other flocks, they were included.

Experiments were undertaken to determine whether such outbreaks can be suppressed by vaccinating exposed birds, and whether the vaccine exercises any curative effect upon birds already visibly infected. From December, 1914, to January, 1916, 5,340 birds were treated, of which 2,033, or 38.09 per cent, were visibly infected. Some septic trouble

followed the vaccinations in two flocks of 816 birds, which so complicated matters that in our published accounts we have excluded them from consideration. In the treatment of the remaining 4,524 birds, of which 1,761, or 38.94 per cent, were visibly infected, the undertaking was successful. The spread of the disease after vaccination was negligible. The mortality was 373 birds, 8.24 per cent of the entire number, 21.18 per cent of the visibly infected ones. While exact mortality figures are not available, contagious epithelioma is everywhere regarded as a serious disease with a high death-rate. Not infrequently the greater part of a flock will perish in an unchecked outbreak. Therefore the results of the experiments appear very favorable. This work has been published as Nevada Agricultural Experiment Station Bulletins Nos. 82 and 84.

There is considerable uncertainty regarding the identity of the conditions encountered in this work. The virus which causes contagious epithelioma cannot be grown artificially as can the ordinary bacteria, but can only be cultivated upon the skin or mucous membrane of the heads of live chickens. There are undoubtedly certain bacterial infections which produce tissue changes of the mucous membrane of the head which are indistinguishable, except by chicken inoculation, from those caused by the former virus, which for convenience of designation we term "scab virus." That point our inquiries have amply demonstrated. Some investigators claim that the various affections known to poultrymen as contagious epithelioma, or chicken-pox, roup, diphtheria, sore head, swelled head, etc., are all caused originally by infection with the "scab virus" complicated by secondary bacterial infections. Some even go so far as to claim that were it possible to have pure "scab virus" infection without the secondary infection the disease would be mild; but that theory is purely speculative, as the conditions are impossible of realization. Some of those who hold the latter opinion believe that outbreaks can be controlled by treatment with vaccines prepared to combat the bacterial infection, disregarding the "scab virus." In our earlier work we assumed that the opposite was true, that if the primary infection with "scab virus" was properly combatted the outbreak could be suppressed, but our results indicated clearly that the vaccines must contain not only "scab virus" but the bacteria responsible for the secondary infections, in order to be effective as a curative agent. However, we have latterly encountered outbreaks, indistinguishable clinically from those in which "scab virus" plays an important role, where the latter could not be demonstrated.

In that type of infection where "scab virus" plays the principal role there will be extensive tissue changes with but little constitutional effect. The appetite remains good, there is but little dejection, and affected young birds grow in spite of the trouble. Death usually results from the mechanical stoppage of respiration, or the birds become blind and starve. On the other hand, we sometimes find an outbreak of bacterial infection in which the tissue changes are slight, with severe dejection and a high death-rate due to intoxication. In the first type "scab virus" vaccines are effective; in the latter they accomplish nothing, but treatment with bacterins prepared from cultures isolated from the infected flocks are effective.

In one flock, referred to in our last annual report, 441 birds were treated with "scab virus" with but little benefit. Bacterins were not

tried. In another flock of 1,526 birds "scab virus" vaccine proved ineffective, but bacterin treatment yielded most gratifying results. In another flock of 177 birds, and one of 200 birds, the same results followed the use of bacterins. Still another flock of 525 birds has been treated similarly, but too recently to know the outcome. Another flock of 94 birds is under treatment. In this flock the "scab virus" infection was present. Some were given "scab virus" vaccine, some bacterin, others combined treatment. The two latter are apparently yielding the more favorable results. In these later experiments we have treated 2,963 birds in addition to those above cited.

Evidence is thus accumulating that we are dealing with a group of infections rather than a single specific infectious disease.

We have undertaken some studies of the "scab virus" to determine its filterability, thermal death-point, effect of prolonged maceration in glycerin, specific serum reaction, and the possibilities of growth inside the bodies of chickens, but as those studies are incomplete we are not ready to announce the results.

PROJECT 21—ANTHRAX-SERUM PURIFICATION

This project represents an effort to refine and concentrate antianthrax serum along the same lines employed in the preceding project. It would appear that, if this can be done, antianthrax-serum globulins would be decidedly preferable to raw serum. That it can be done appears logical.

A small amount of work has been done under this project. One lot of serum was processed by fractional precipitation with ammonium sulphate, splitting the globulin content into its euglobulin and pseudoglobulin fractions. That experiment indicates that the globulin content of antianthrax serum differs in certain of its properties from hog-cholera serum. Of the various antisera to which this method of separation of the active principle may prove applicable, we may find that each requires a somewhat different treatment. It is our intention in conducting this project to utilize only the time not required by more pressing work. It may, therefore, be some time before data are accumulated.

THE STATE VETERINARY CONTROL SERVICE

The organization of the veterinary activities centered at the University is somewhat unique. The financial arrangement which supports it is complex. It is efficient and sufficiently flexible to meet whatever situation may develop with respect to infectious diseases of domestic animals. Its efficiency and flexibility warrant the arrangement and, while certain features depend upon mutual agreements with certain livestock interests rather than upon statutory provisions, the arrangement secures the cooperation of those interests in our entire program, serves all interests satisfactorily, and has advantages which more than offset any inherent defects.

Briefly stated, the plan and work of the organization are as follows:

With the single exception of the control of diseases peculiar to sheep—which is exercised by a State Board of Sheep Commissioners—all the veterinary activities of the State are centered at the University under the direction of the writer. This includes the instruction of agricultural students in veterinary subjects; the research work of the Agricultural Experiment Station; the work of the Agricultural Extension Division in animal diseases; the diagnosis of infectious diseases of domesticated

animals; the control of outbreaks of those diseases; the preparation, distribution, and use of hog-cholera serum and other sera and vaccines; and the exercise of the quarantine function, both intrastate and interstate.

This arrangement makes us responsible for the control of all outbreaks of infectious diseases except those peculiar to sheep; in the case of a disease affecting several species of animals, including sheep, responsibility rests upon us. It enables us to apply immediately any knowledge gained through experimental research to the actual control of the diseases being studied, relieving us of the embarrassment which might result from prematurely placing such information at the disposal of persons not responsible to the administrative head of the department. It places at our disposal for research purposes any and all material which may develop in the State; places every infected herd at our disposal for testing preventive and control measures, insuring to the owners of those herds the use of the most modern methods; enables us to conduct certain features of our research projects upon a commercial scale, thus rendering the data more valuable than those which can be secured from the small number of animals we are able to purchase for experimental purposes; correlates the research and extension activities, insuring uniformity of instruction and practise.

It is important that we be able to utilize the material from outbreaks of infectious diseases, not only in the conduct of projects already under way, but as sources of information as to the necessity for undertaking new ones and the preliminary studies incident to a decision as to the necessity for so doing. In the use of our herds for testing the newer immunizing agents, discretion and judgment are essential, as no reckless experimentation is permissible under any circumstances. The several veterinarians connected with our work are kept fully informed and in close touch with the progress of the research work and field practice by frequent conferences and otherwise. The uniformity of opinions and information secured by close contact and frequent interchange of views among the several men thus engaged is important. It is unfortunate when several persons engaged in closely connected work teach various and conflicting theories and practise. Such a situation tends to lower an institution in the public esteem, as it fails to inspire the confidence so essential to success.

For the first eight years of its existence this department was a one-man affair, financed almost entirely from the Adams Fund, which provides only for research. During that time considerable research work was accomplished, an acquaintance with many livestock owners established, a familiarity with the needs of the industry in the State with respect to infectious diseases gained, and the foundation laid for affording real assistance in the control or eradication of those diseases. This is the ultimate object to be attained by the department—the reason for its existence.

During the past two and a half years our work has expanded rapidly. There are now four veterinarians on our staff on full time in addition to the writer, and the services of two or three practising veterinarians are available as needed, beside an office assistant, a laboratory assistant, and a laborer. We have been given larger quarters, increased and additional equipment, more money with which to conduct our work. The funds for more liberally financing the department are derived from various sources, much of it from outside the University. With the funds thus

placed at our disposal we are able to render efficient service to the livestock industry.

Taking the original Department of Veterinary Science and Bacteriology as a nucleus, we have built around it the present service. The State Veterinary Control Service; the State Board of Stock Commissioners which the writer serves as secretary; the State Board of Sheep Commissioners; the State Rabies Commission; and certain private livestock corporations—all cooperate and contribute to the work. The arrangement gives great flexibility, enabling us to meet any situation which has ever arisen. In case of need the entire force could be utilized to meet an emergency, the statutes of the State providing for the payment of salaries from state funds in such a case.

We examine any suitable material submitted for the diagnosis of infectious diseases of animals; investigate reported outbreaks, and assume active control in such outbreaks. Thus we not only exercise the quarantine function, but, after giving an accurate diagnosis, administer vaccine or serum when needed without expense to the owner for services, the owner paying only the cost of materials used. In addition we undertake the study of the more important problems by precise scientific and experimental methods. As our work develops we feel an everdecreasing need for quarantine measures. We believe that when an owner of live stock is confronted with an outbreak of infectious disease he needs expert assistance and advice more than he needs quarantine. Of course, it is advisable to have the quarantine authority in reserve in case of need.

The volume of work this service performs has become large and is increasing. It is of direct value to the industry and is appreciated by the men engaged in it. The superiority of service secured by centering the various activities of the State under a single management over that of a multidirected service is amply demonstrated by the results we have achieved.

DEPARTMENT OF RESEARCH CHEMISTRY

PROJECT 11—RELATIVE FEEDING VALUE OF CROPS OF ALFALFA

For many years the farmers of this State have maintained that there is a marked difference in the feeding value of the separate crops obtained from the same alfalfa field. Nearly all the farmers interviewed assert that the second crop is the poorest feeding material, but find no great difference in the first and third crops.

It was considered worth while to undertake a chemical investigation of the different crops collected from various parts of the State, with a view to ascertain whether or not chemical differences existed that might explain the feeding value of these crops. Over one hundred samples of different cuttings of alfalfa have been included in the work. The data already at hand warrant us in making some far-reaching generalizations.

Without taking into account the results obtained from the crude-fiber determinations upon the various cuttings, we may say that a perfectly clear and definite relation exists between the ash and nitrogen content of the different crops of alfalfa.

Large variations were found in numerous samples of the same crop. These particular samples, showing marked differences in ash or nitrogen from others of the same crops, may have been grown under wholly different conditions not known to us, and errors in the analyses might also be responsible for some of these differences. However, when all the analyses of the first crop are summarized, it is seen that the average thus obtained for both ash and nitrogen is higher than for the second crop, but lower than for the third and fourth crops. The actual averages for ash are the following:

Crop 1	*Crop 2*	*Crop 3*	*Crop 4*
8.07%	7.75%	8.32%	9.37%

For nitrogen:

Crop 1	*Crop 2*	*Crop 3*	*Crop 4*
2.40%	2.27%	2.61%	3.18%

Furthermore, it will be seen that a practically constant ratio exists between the ash and the nitrogen for the different cuttings, namely:

Crop 1	*Crop 2*	*Crop 3*	*Crop 4*
3.1	3.4	3.2	3.0

From these results we might be justified in drawing the conclusion that the feeding value of the crop lies not only in the nitrogen content but in the ash content as well. On this basis the fourth crop should be the best feeding material, the third the next, then the first, and lastly the second crop. This order has virtually been established by the farmers of this State in their feeding practise.

It will be interesting to learn if the crude-fiber determinations of the different crops will show the same relation. If so, we might expect to find the highest percentage of crude fiber in the second crop, the next highest in the first, then the the third, and least in the fourth crop. Whether this hypothesis can be verified by experiment remains to be seen.

Enough has already been done upon this project to offer a reasonably sure method of analysis for any given alfalfa crop in this State. In other words, if it is desired to find out whether or not a given load or stack of hay is first, second, or third crop, the determination is a simple one. Furthermore, if the results obtained are criteria of the feeding value of the hay, which now seems probable, it would be just as easy to determine chemically the feeding value of any alfalfa hay, irrespective of the crop, in terms of these general averages. Work on this project will be continued.

PROJECT 13—CHEMISTRY OF NITROGEN FIXATION BY ALFALFA

This project comprises a chemical study of alfalfa with a view to learn and control the intricate mechanism by which the plant abstracts and utilizes the nitrogen in the atmosphere. A great deal of work has already been done upon this project, various constituents isolated, and characterized. This project is considered practical only in a remote sense, and for that reason a very limited amount of time has been allotted to it during the past year. The chemistry of alfalfa saponine—a constituent of alfalfa—has been completed, but the work is not yet published. This saponine is similar in many respects to the saponines of other plants, but different in others.

For example, alfalfa saponine, like most other saponines, is soluble in water, giving a strong foam on the water when shaken with it, which lasts for some time. Like solanine, it is a nitrogenous saponine showing a slight alkilinity with sodium alizarin sulphonate, but neutral to litmus and phenol phthalein.

Alfalfa saponine gives the various color reactions of other saponines and is hydrolized to glucose and a sapogenine by acids, but with respect to its hemolizing property it differs from other saponines, and this one property renders other saponines unfit for use in soda fountains as foam producers on soft drinks. Alfalfa saponine does not hemolize blood and is, therefore, not poisonous like other saponines.

In cooperation with the Veterinary Department of this Station, I have investigated this property of alfalfa saponine very carefully.

This saponine might find use in soda fountains and elsewhere as a foam producer, since it has been found to be harmless when administered to animals. Alfalfa saponine also differs from other saponines in that its ash is composed of calcium and magnesium almost exclusively, while the ash of other saponines is composed largely of sodium and potassium. Other chemical and physical properties of alfalfa saponine have been determined and the work is now ready for publication.

A saponine X obtained in the purification of crude alfalfa saponine has a yellow color, an ash content of 25–30%, and possesses laxative properties. This substance has not been studied further.

PROJECT 14—PLANT POISONS

This project has received major attention during the past year, the work having been divided between death camas, lupines, golden rod, and rabbit brush—four classes of poisonous plants that have occasioned more or less loss among sheep in this State.

Death Camas—Every spring sheepmen report some losses in their herds due to death camas. This plant, whose botanical name is *Zygadenus intermedius Rydg.*, was collected at different periods of growth and

tested with respect to its poisonous qualities. The determinations led to the following positive conclusions: The plant is poisonous at all stages of growth. The leaves prior to blooming are poisonous, and this fact should be given careful consideration by sheepmen, for death camas appears among the very first plants on the range in the spring.

Sheep avoid eating this plant unless forced to do so by lack of other forage or upon forced drives. At the blooming period all parts of the death camas are poisonous. The flower cluster was found to be the most poisonous per unit weight of material, the tubers the next, and then the leaves. The stems were the least poisonous. After the plant had reached the seeding stage, the seeds were the most poisonous. The tubers appear to be poisonous at all times; but, since they are generally four to six inches below the surface of the ground, they play no direct part in the poisoning of range animals. Whether or not the woody stems of the mature seeded plant are poisonous was not considered worth while to determine, for they are so fibrous and tough that they are not likely to be eaten under any circumstances.

A considerable quantity of material was collected last spring, but on account of the heavy frosts late in the season it was considered unsatisfactory for our purposes in producing normal results. The alkaloidal extract obtained from this lot yielded a much smaller quantity of reasonably pure alkaloid and the physiological properties of the same were less pronounced and unlike those from fresh and unaffected death camas.

Twelve different physiological tests were made upon rabbits, using this material, but the results were such as to lead us to postpone the death camas work to another season when material unaffected by frosts and drought might be secured.

Lupines (*Lupinus sp.*)—In this State the spring and summer of 1916 was unusually dry with several late frosts, which rendered the forage and plant life in general upon the range poor and scanty. How the death camas was affected has already been discussed. The lupines were affected in a somewhat different way. The yield of pods and seeds for a given area was perhaps not more than one-half or one-third of the normal. This was not the only difference, for, when the man who had been sent to collect lupine pods for our work brought them in, we found that fully nine-tenths of the pods were wormy and a large number of the seeds had been completely devoured. The man was sent out on a scouting expedition to try to locate other areas of the blue lupine where the seed pods might be unaffected, but without success.

Physiological tests were made of extracts from the blue lupine leaves and flowers prior to the seeding stage, and they were found to be nontoxic to rabbits.

Extractions were then made of the affected seeds and pods to isolate the lupanine hydrochloride which we had obtained in crystalline form in small quantity the year before. To our surprise only a very small quantity was obtained after working up the entire lot of lupine pods gathered. It was not enough to accomplish anything chemically. The residues and extracts were worked over again and the products tested out on rabbits by Dr. Records, but without a sign of poisonous qualities. Four such physiological tests were made on the different products obtained and, since all were negative, the products were all thrown away and the work on lupines postponed until a time when healthy material could be secured.

Golden Rod (*Solidago spectabilis*, *Gray.*)—Having had little success with both death camas and lupines this year, we still had a third variety of poisonous plants to consider, namely, a species of golden rod, which had been found to cause the death of a number of sheep the season before.

Sufficient golden-rod material for study had been collected in October, the month when the poisoning occurred. This material was worked over with a view to the isolation of an alkaloid that might have been the cause of the poisoning. Extractions were made with ether, chloroform, and alcoholic-hydrochloric acid, and each worked up separately for the separation of alkaloids from the residues. In each case a reddish-brown resinous material was obtained, which was tested toxicologically by Dr. Records of the Veterinary Department.

Four such lots of supposedly alkaloidal residues were obtained and tested out on rabbits, but with uniformly negative results. This seemed to us conclusive proof that no alkaloid was present in the golden rod in sufficient quantity to produce the observed toxic effect on sheep, unless sheep are poisoned by a substance to which rabbits are immune.

In the course of the preparation of one of these products from *solidago*, using 95 per cent alcohol as solvent, a brownish extract was obtained. When concentrated and poured into dilute tartaric acid to combine any alkaloid that might have been present, a white crystalline substance was obtained by concentrating the tartaric-acid solution after the tar had been separated. It was thought that this crystalline product, having no resemblance to tartaric acid itself, might be an alkaloidal tartrate with poisonous properties. Dr. Records gave 0.5 g. of this to a rabbit in a gelatine capsule by mouth and in about a week the rabbit died. A sheep to which we gave 1,000 g. of leaves remained normal for almost forty-eight hours before exhibiting signs of poisoning, showing that the substance is a slow-acting poison. From this the conclusion was drawn that we had found the poisonous principle.

The next few weeks were spent in isolating a sufficient quantity of the material for work. To make sure that this substance was really the poison, we again tried it on a rabbit, but, greatly to our surprise, the animal exhibited no abnormal symptoms. A second trial gave the same negative results, when it became evident that the poisonous principle in golden rod was still to be discovered.

The idea then occurred to us that the poison might not necessarily be organic in character, but rather a superabundance of some inorganic element which could be recovered and quantitatively determined in the ash resulting from the incineration of the plant. This idea was followed out and to date we have accumulated enough evidence to warrant the statement that the poisonous principle in golden-rod leaves is potash or iron, or both. This question we hope to settle in a few weeks and then publish in bulletin form the complete data obtained.

Poison Alkali Brush (*Tetradymia glabrata*, *Gray.*)—A new poisonous plant was discovered this year. The discovery cost a local sheepman more than 1,100 sheep, and the cause of the poisoning remained in doubt for some time until the idea occurred to us that it might be due to potash obtained by eating the tips of this brush.

Careful analyses were made for potash upon the liver, blood, ascitic, and pleuritic fluids of the poisoned sheep, and all were found to be abnormally high in this element. The tips of the poison alkali brush

were analyzed for potash, and found to run 25.9 per cent soluble potash in the ash, equivalent to 2 per cent chloride of potassium in the green twigs.

A healthy sheep was fed 1,900 grams of crushed and macerated tips with fatal results, and the analysis of corresponding parts of this sheep showed comparable, if not identical, values of potash. Although other causes of the poisoning might not be wholly excluded, our work evidences a strong probability that potash in the poison alkali brush tips was the cause of the poisoning.

General Remarks—This department was fortunate in having provided a good supply of chemicals and apparatus prior to the war, and consequently very few items have had to be supplied at the present high prices. Enough of the more expensive chemicals is now on hand to last another year.

Mr. George H. Hopkins, a student, has assisted me to the extent of about fifteen hours per week during the college year upon Project 11. Mr. A. C. Wilber has been student assistant in the department during the year, spending about the same amount of time upon general laboratory routine. As in the years past, about one-sixth of my own time has been devoted to teaching.

DEPARTMENT OF METEOROLOGY

PROJECT 12—SNOW STUDIES AND SNOW SURVEYING

The entire year has been spent in completing and analyzing data obtained during the past several years in studies relating to the conservation of snow and the forecasting of seasonal run-off. Special appropriations generously made by the Director for student assistance will make possible the early completion of two bulletins—(1) The Evaporation of Snow; and (2) Snow Surveying: Its Problems and their Present Phases—which should be credited to this year. However, the completion of the remaining bulletins will depend upon the obtaining of further appropriations or occasional opportunities to continue the analyses of the data.

The data being analyzed fall into three main divisions:

(1) The Evaporation of Snow;

(2) Snow Surveying and Forecasting of Stream Flow; and

(3) The Relation of Mountains and Forests to the Conservation of Snow.

To these should be added:

(4) The Avoidance and Prevention of Frost—which has been maintained from state funds.

(1) Evaporation of Snow:

The study of the evaporation of snow, being fundamental and preliminary to the other snow studies mentioned, has received special emphasis. Furthermore, because of the exceptional dryness of the atmosphere in regions where irrigation is necessary and the slight attention so far given to the evaporation of snow, endeavor has been made to establish a normal for the semiarid West and to perfect the technique.

The comparative rate of evaporation under various conditions of forestation and elevation has been determined; likewise of ice, snow, and water under similar conditions. Evaporation in tree crowns has been briefly compared with evaporation from the snow on the ground.

The effect of hoods on pans in apparently accelerating evaporation has been studied at length, as has the effect of allowing the contents of the pans to melt.

This work should be continued sufficiently long to determine more exactly the relationship between the evaporation in the higher and lower levels of mountain watersheds and the approximate normal for the mountain system. No attempt has been made to determine the exact relationship of the various elements of wind, temperature, and humidity to evaporation, though a few obvious comparisons have been made. The atmospheric elements, as found in the field, are so complex that laboratory control must be had to isolate each element and determine its effect.

(2) Snow Surveying and the Forecasting of Stream Flow:

As pointed out a year ago, the study of snow surveying has inevitably fallen into the two main divisions indicated by the joint title given.

a. Snow Surveying—The first division, "Snow Surveying," has now been brought to a logical conclusion, and the accuracy of the method has now been established. A snow sampler of sufficient length and lightness has been developed to measure all snows ordinarily found. Further-

more, a special cutter has been perfected, so that snows of all densities and ice crusts can be readily penetrated without loss in the core. Finally, the use of sections makes the sampler convenient to handle, however shallow or deep the snow may be.

The search for the ideal location for courses along which to survey has been continued. The heavy winds of last winter have demonstrated the need of choosing wherever possible open flats protected from erosion by the presence of encircling slopes and forests, yet sufficiently removed from overhanging cliffs to prevent overloading by snow blown from their crests. Courses on exposed slopes have been found erratic and have a possible maximum error of 20 per cent unless the average of several slopes is taken.

b. Forecasting of Stream Flow—The season of 1915–1916 has made it obvious that the snow cover on the mountains does not necessarily indicate the stream flow to be expected, for certain types of weather exercise a preponderating influence on the amount of water that finds its way from the snow-fields to the channels of the streams below. For example, the snow-fields represented 144 per cent of normal, yet the rise of Lake Tahoe—in whose basin the survey was made—was only 103 per cent of normal.

The cause was traced to lack of precipitation during the spring on the lake's surface, to excessive evaporation, and finally to the probable waste in run-off caused by prolonged freezing after run-off had begun and to the absorption of additional moisture in repriming the soil.

The present season of 1916–1917 will evidently afford a striking illustration of the effect of retarded, but not interrupted, run-off on stream flow.

To determine the exact relationship of the weather to the run-off, a series of late spring and early summer snow surveys was inaugurated last year at typical stations and a comparison begun of the disappearance of the snow and the rise of the lake. This series is being continued the present season. Since the Tahoe basin is largely a water basin and is, therefore, unduly subjected to water evaporation, similar surveys should be conducted in the adjacent Carson basin, whose surface is land.

To pursue this problem in retrospect, a table is being made showing the percentage relationship of the annual and monthly stream flow of the Walker, Carson, Yuba, American, and Mokelumne Rivers which head in the Sierra Nevada near Lake Tahoe. However, shorter periods even than months will be necessary to show in detail the effects of weather on the acceleration and retardation of stream flow. Because of the lack of exact measurements of mountain snowfall prior to the inauguration of snow surveying, this retrospect is limited to recent years.

The practical value of snow surveying to agriculture obviously lies in exact information regarding the minimum amount of water available for the season. In the case of lakes and reservoirs whose inlets are much larger than their outlets, it will be possible to revise the forecast some days or even weeks in advance, so that the highest level can be maintained without risk of overflow. In the case of streams whose flow must be utilized as it comes, the forecast must necessarily be more general in character; yet some revision can be made between the time of the spring snow survey and the planting of crops. At least, the agriculturalist can be freed from the alarm of lack of water, because the run-off is late in starting.

(3) *The Relation of Mountains and Forests to the Conservation of Snow:* Although many tables have been projected and partly completed, attention has been given primarily to checking and arranging the data to show the evolution of the snow during the periods of accumulation and melting at various elevations and under various conditions of forestation. In a plan of such scope many gaps must necessarily occur. Furthermore, the larger problems of seepage and transpiration, which have been studied by others, have not been entered upon. Emphasis has been placed rather upon the study of the efficiency of forests of various types in conserving the snow cover against early melting where there is no reservoir below to impound flood waters. Only when the snowbanks have become greatly isolated and the underlying soil dry, is there probably any considerable loss in the snow. At least the losses due to continued evaporation and transpiration seem to be amply compensated by the retardation in melting.

The conserving power of the fir tree, whose foliage is particularly dense, was amply illustrated during a recent trip to Ward Creek to observe the melting of the snow under conditions of unusually high temperature. While the deforested slopes had already become dry on the surface and the meadow lands were a quagmire, the snow-fields where protected from the sun and heat by the continuous fir were still firm to tread upon even in the middle of the afternoon.

When the bulletins on evaporation and snow surveying have been completed, such time as is available will be given to the further analysis and publication of the accumulated data.

(4) *Temperature Survey and Frost Studies:* The temperature survey has been continued at the stations reselected in 1915. These include most of those established originally in the Truckee basin and additional ones in the lower Truckee and Carson basins established in 1915, in cooperation with F. B. Headley, Superintendent of the Truckee-Carson Experiment Farm (Bureau of Plant Industry).

The effect of low temperature upon blossoms and setting fruit was studied again during the occasional frosts that prevailed this season. On the night of May 15 occurred the most severe frost of the season. The plums, peaches, and pears were in full bloom, and in the case of the green gages the petals had fallen. The apples were mostly in large buds or full bloom. Approximately one-fourth of the buds were medium. Where orchard heating was not employed, the temperature fell to 24°–26°. Yet approximately half of the crop of apples and plums survived. The pears were uniformly destroyed.

The few who heated their orchards even with makeshift appliances had no trouble in saving their entire crop. The writer practised the utmost economy of fuel in his orchard to see how little expense would be necessary to save the crop. The plums were not protected at all until the temperature of 30°F. was reached, and then only with a single heater to each tree. The peach tree was heated at 28.6°; the pears and crab-apples at 27.6°; and the apples at 26.6°. Owing to the fact that the trees bearing similar kinds of fruit were scattered, the efficiency of the heating was necessarily lower than when heaters were used in groups. At one time the temperature in the orchard was allowed to fall to 26.4°, but was soon raised to 28°, which was not exceeded during the remainder of the night. The minimum temperature outside of the orchard

fell to 24°F. The heating was begun at 12:45 a. m. and ended at 5:25 a. m. Not over fifty gallons of distillate No. 18 were used, the cost being $2.75.

The fruit, including currants, was all saved, except the green-gage plums, which were too remote from the heaters to gain the full benefit of the heat, and the pears, which were evidently heated too late. Yet the plums and the pears will be half a crop. It is interesting to note that the pears on the lowest and highest branches of the trees were injured, the former suffering during the early stages of the frost and the latter during the later. The blossoms in the middle branches of the trees, which were easily reached and protected by the heaters, were wholly protected.

From this experience, which repeats earlier ones, it seems that, under the conditions of humidity prevailing in this section, fruit probably withstands injury here more readily than elsewhere. This fact should be tested by experiments under laboratory conditions.

A survey of the fruit on the trees made later in the season proved yet again how slight is the effort usually necessary to save the crops. Over most of the Truckee-Carson Project there was a fair crop of fruit, the only exception being its lowest district, The Island, where practically nothing survived. On the higher slopes near Hazen even apricots were found. East of Reno, at the Nevada Hospital for Mental Diseases, the trees on the higher ground were well loaded. West of Reno, where the valley is high, only the early blossoming apples were injured. In Carson Valley, which is somewhat more exposed to frost than the districts to the north, the trees bore one-half to two-thirds of a crop.

The most striking incident of the season was the survival of the Montmorency cherries at Dr. A. E. Hershiser's residence in Reno, though other fruit in the yard was killed. If these cherries are immune to the degree of frost that occurred there this season, they should be a profitable fruit to grow in this portion of the State.

It seems at least a pity, when food of every kind is being conserved to meet the exigencies of the war, that no endeavor whatever was made by most owners of orchards to save their fruit. Those who made the attempt were rewarded by a full crop of fruit for less than five hours work.

In exposed situations, alfalfa, peaches, and raspberries were winter-killed, in some instances evidently during the long period of cold that prevailed in January. At Fallon the tamarisk, a hardy windbreak, was frozen to the ground. In the situations less exposed, probably owing to increased protection from the wind, no damage was noted. This was particularly true of the raspberries in the writer's orchard. Probably a windbreak would have afforded complete protection.

The data being gathered on temperature and frost occurrences during the past several years should now be analyzed and published. To do so will require an appropriation of approximately $300 for student assistance in tabulating the data for final analysis. The cost of publications will be extra.

Cooperation—Cooperation has been continued during the year with the Truckee-Carson Experiment Farm at Fallon, which is maintaining the temperature survey on the Truckee-Carson Project. Cooperation has also been maintained with the Reclamation Service in snow surveying at Lake Tahoe. The Weather Bureau, however, abandoned its cooperation in snow surveying in the Carson and Walker basins and in the evaporation

of snow for the method of accumulative snowfall (without reference to density).

On the other hand, the Meteorological Service of Canada has formally adopted the method of snow sampling for its mountain stations, and the United States Forest Service is planning to inaugurate snow surveys in the San Joaquin and Kings basins. Inquiries have also come from the Engineering Department of the State of California and from the University of Lausanne, Switzerland. Finally, at the request of Dr. deQuervain, who is using a Mount Rose snow sampler in the study of the growth of glaciers, an ice cutter has been perfected which will cut through crusts of ice one and one-half inches thick without compressing the core. This addition finally perfects the Mount Rose sampler so that it is equally usable and efficient in snows of all types and to the maximum depths usually found.

Publications—Bulletin 83, Technical, by Professor Fergusson, on "The Value of High-Level Meteorological Data in Forecasting Changes of Temperature," was honored during the year by being reprinted at length in Scientific American Supplement No. 2152, March 31, and No. 2153, April 7. This bulletin has also been requested by some forest service stations for its mountain climatological data.

The paper read in January, 1916, before the Second Pan-American Scientific Congress on "Snow Surveying: Its Problems and Their Present Phases," is being published in full with some tabular appendices in the proceedings of the Congress. The manuscript has also been widely circulated for the purpose of receiving and giving suggestions.

Finally, a bulletin on the evaporation of snow and another embodying a revision and further extension of the manuscript on snow surveying will shortly be ready for publication.

Future of the Work—Irrespective of the future of the department, the future of the work seems assured. The increasing interest in the methods inaugurated by the department shown by the United States Reclamation Service, the United States Forest Service, and the Meteorological Service of Canada, and plans already formed, indicate the inauguration of snow surveys on a large scale throughout the Pacific Coast and western Canada.

The department will be continued privately for a time until the present projects are completed, in case additional assistance now under consideration by the University cannot be granted. The Reclamation Service also is considering the plan of financing the work in the Tahoe basin as a Tahoe snow laboratory and conducting it jointly with the department.

DEPARTMENT OF ENTOMOLOGY

PROJECT 19—BITING FLIES OF CATTLE

On June 1, 1916, the Department of Entomology secured the approval of the Office of Experiment Stations, Washington, D. C., for a joint project to be undertaken by the Bureau of Entomology and the Nevada Experiment Station in the study of certain biting flies of cattle. These flies afflict the cattle on mountain pastures to such an extent that they do not put on flesh, even in midsummer on excellent grass. The cattle bunch together and stop feeding when the flies are at their worst, and they are kept on the move, restless and annoyed when feeding. Naturally enough, they do not make the gains to be expected from the character of pasturage.

These flies, nearly all of which belong to the family *Tabanidæ*, are notorious for the injury and annoyance they cause in this and other ways. They are large, blood-sucking flies whose maggots are supposed to live in mud and stagnant water, or even in running streams. Since the habits of the local blood-sucking horse- and cattle-flies are not well known, and nothing is known about their breeding places and their earlier stages of growth, it appears that a careful study of their habits and breeding places may make it possible to use artificial measures for the reduction of their excessive numbers. On the other hand, control may prove to be impracticable. This project will naturally include two principal lines of work:

I. The study of the life-histories and habits of the principal species of biting flies involved, with special reference to the following points:

(1) Egg-laying habits of the flies; length of egg-laying season and duration of the egg state.

(2) Habits and structure of the newly hatched larva and, in general, of the earlier larval stages.

(3) Duration of the later stages of growth, habits of the maggots, and conditions which are necessary for growth to maturity.

II. A study of methods by which these flies may be trapped or may otherwise be kept from doing injury; with studies of methods of destroying the earlier stages of the flies, their eggs or larva, by draining low-lying pools and swamp lands, or by using oil or lime in such waters, or by any other means indicated by the habits and life-histories of these insects.

This matter of injury due to biting flies of cattle is one which touches agriculture in two principal ways: (à) The flies appear to be active agents in the spread of anthrax in the regions where the studies are to be undertaken. It seems that they may likewise be carriers of hemorrhagic septicemia in cattle and perhaps of swamp fever in horses. (b) Aside from annoyances to horses during the harvesting, these insects cause the cattle to stop feeding early in the day and to bunch up and fight flies until well along in the afternoon. This results in very slow gains or even in loss of flesh when the flies are most active. On the whole, the total injury to beef animals on pasture during the height of the fly season,

aside from losses due to the spreading of disease, appears to be considerable enough to warrant the use of active measures to suppress the flies.

On August 22, 1916, field work upon this project was begun by the Nevada Experiment Station and the Bureau of Entomology, United States Department of Agriculture. The problem was assigned to F. C. Bishopp of the Bureau of Entomology, who placed the local work in the hands of Mr. J. L. Webb. In August, 1916, Messrs. Bishopp and Webb visited several localities in Nevada and adjacent portions of California with a view of finding the most suitable location for the work.

After visiting places in the vicinity of Deeth, Nevada, and others on the northwestern border of Lake Tahoe the representatives of the Bureau of Entomology examined other regions in the vicinity of Washoe Lake, Nevada, and the upper Carson Valley, finally visiting Antelope Valley, which lies on both sides of the Nevada-California line. The abundance of the material for study, with the fact that a field laboratory could readily be set up near a store and a postoffice in the very midst of the fly-infested region, led Messrs. Bishopp and Webb to choose Antelope Valley as the location for the field station where active work upon this project will be continued. A basis for cooperation between the Nevada Experiment Station and the United States Department of Agriculture was decided upon.

Field headquarters were established in Antelope Valley with the understanding, however, that the biting-fly conditions are to be studied in other parts of Nevada and California as may be necessary. It was at first planned to establish cooperative relations with the Antelope Valley Land and Livestock Company, but on the whole it seemed most desirable that the work should stand on its own feet and that all supplies and labor obtained from farmers and livestock men should be paid for from the funds of this project. This leaves the Station free to choose other localities for the work and to move field equipment from place to place as the need may be felt without being hindered by local obligations. We are, however, much indebted to the stockmen of Antelope Valley for kind and courteous treatment and continued intelligent interest in the work.

In April, 1917, Mr. Webb was given authority by the Nevada Station to proceed with the purchase of materials and supplies for an insectary. It was planned that the entire cost of the building should not exceed $250. During the winter an admirably complete plan was outlined by Messrs. Bishopp and Webb and Dr. W. D. Hunter of the Bureau of Entomology, embodying all suggestions made by the Director of the Nevada Station. Throughout the late spring and early summer of the present fiscal year active work has been in progress in the field laboratory at Antelope Valley, where Mr. J. L. Webb has made excellent progress in the study of the life-histories and habits of the insects concerned. Mr. Webb has been assisted by Mr. Rufus Ogilvie, a student in the University of Nevada.

There is is every prospect that it will be necessary to continue these studies patiently for a number of years in Antelope Valley and in other portions of Nevada or California before it will be possible to base recommendations for the control of the insects upon sound observation and experiment.

Alfalfa Insects

Very few complaints of injury due to alfalfa insects reached the University in the present fiscal year. Cutworms did comparatively little

damage, and on the whole the State's alfalfa crop was injured far less than usual by insects which infest the fields. This was particularly fortunate because of the scarcity of alfalfa hay and the resulting high price. Studies of insect injuries to alfalfa will be continued from year to year as the situation in the State varies.

Insect Injuries to Home Gardens

There has never been a year in the history of the University when so many calls have been made on the Department of Entomology for special assistance and advice as in the year 1917. This was due to the fact that throughout the State patches of garden stuff were planted by amateur gardeners who had little or no experience with the control of insect pests. Cutworms were abundant. Cabbage-lice and cabbage-worms were found almost universally. Tomatoes were injured by the tomato horn-worm, while radishes, turnips, beans, and sweet corn were injured by the sweet-corn maggot and other related insects. As the entomologist of the Station is also the Director, it was particularly difficult to give sufficient time and attention to the garden-insect troubles and to care for them properly.

In this emergency Dr. P. A. Lehenbauer of the Department of Biology of the University of Nevada showed an excellent spirit of cooperation and volunteered his services to the Department of Entomology in the Station. During the period when these garden pests were most active Dr. Lehenbauer worked unselfishly and unceasingly to check their ravages. Such work can be done best only by personal visit, especially with amateur gardeners. Dr. Lehenbauer demonstrated methods of preparing poison baits for cutworms and with Mr. C. G. Vinson of the Agricultural Extension Service demonstrated practical methods of spraying for plant-lice and cabbage-worms. Dr. Lehenbauer's resignation, to take an advanced position with the University of Illinois, was a distinct loss to the University of Nevada; and when Mr. Vinson was called to the colors on October 15, 1917, his loss was felt alike by the Experiment Station and by the Agricultural Extension Service, of which he was a valued member.

DEPARTMENT OF RANGE MANAGEMENT

The Department of Range Management is the youngest department of the Nevada Agricultural Experiment Station, having been organized during the latter part of February, 1916.

The first work was necessarily that of organizing the department—both office and field—and the development of working plans. After the office and field equipment was purchased and installed, a number of trips on horseback and by wagon were made for the purpose of determining what are really the big problems, so that all of the investigations will have a direct practical application to Nevada's livestock industry.

It was observed that from one end of the State to the other the public grazing lands have been badly abused and the carrying capacity materially reduced, due to (1) overstocking; (2) repeated grazing causing injury by excessive hoofing; and (3) grazing at the wrong time of the year.

Figure 6—Sheep grazing on fall range just before going down onto the desert

Under our present laws any person may graze any amount of stock at any time on any part he pleases of the public domain. This has resulted in overstraining or overstocking the grazing capacity of the range land. The net result has been a pronounced decrease in the number of stock produced on the public lands. The present depleted condition of the public grazing grounds is due to the lack of an intelligent orderly system of handling stock on these lands. The principal reason why a proper grazing system has never been evolved for the public lands is the peculiar legal status of the occupancy and use of these lands.

The Federal Government, although the owner of the public grazing lands, has taken no steps to bring about an improvement in their condition. The present high cost of meat and the prospective increase in

that cost makes it a public duty for the Government to enter this neglected economic field. What is needed is legalized control of the public domain, be it either federal or state.

The necessary form of range control through federal legislation should provide authority for constructing fences, water-holes, weaning pastures, etc., necessary to handle properly, protect, and control the stock on the range; and, further, it should provide assurance that the stockmen, who construct the permanent improvements necessary to handle and control their stock, will have use of the range for a period of years long enough to make the advantages of control more than offset the cost of construction and maintenance in money returns to the individual, or that the use of the range will not be terminated without ample provision for reimbursing the individual for money expended in constructing the range improvements.

By such a system of range control, it will be possible to adopt a plan of utilization which will provide the necessary forage for running a definite number of stock each year, and at the same time maintain the maximum carrying capacity by allowing the important range forage plants to grow to full maturity as frequently as consistent with utilization.

It will abolish that form of range management or range practise which has been followed over all of the open public lands and which has been cumulatively destructive, so that today many of the finest summer and winter ranges have been absolutely denuded of all or most of the palatable forage. Further, by a regulated system of range management the loss from starvation will be reduced to a minimum, a better grade of animals will be handled, the calf crop will be increased, the cost of handling will be reduced, the ranges will receive necessary improvements in order to utilize the range forage most efficiently; and, lastly, it will stimulate the establishment of new home units in the form of stock ranches.

The following are the six approved investigative projects assigned to the Department of Range Management:

Project 6—Poisonous Range Plants;
Project 7—Reestablishment of Native Range Forage Plants;
Project 8—Relative Importance of Native Range Forage Plants;
Project 9—Introduction of Foreign Range Forage Plants;
Project 10—Carrying Capacity of the Range;
Project 20—White Sage Studies.

PROJECT 6—POISONOUS RANGE PLANTS

The investigation of poisonous plants naturally involves many lines of study, but those which mainly concern this department are (1) the species which are poisonous to stock; (2) the stages of growth in which each species is poisonous; (3) the class of stock to which each species is poisonous; (4) the habitat and distribution of each species; (5) the life cycle of each species; (6) methods of range eradication; (7) the conditions under which range losses occur; (8) the best methods of handling to reduce the loss to a minimum.

All observations to date clearly indicate that a large percentage of the stock losses in the State due to poisonous plants may be reduced if intelligent methods of handling are used. With the present high prices of stock every cowman and sheepman should know all of the poisonous plants on the range. Without this knowledge he cannot possibly handle

his stock to avoid loss from poisoning. If he knows the poisonous plants, he will then know when and where to direct his stock to avoid losses.

The most disastrous cases of poisoning occur during the long drives, when the animals are being moved from one range to another, or after unloading when the animals have been in the cars for a considerable length of time and are ravenously hungry.

It has been noted that when sheep are being hurriedly trailed they eat many plants which under normal conditions are unpalatable. The chance to exercise any choice is removed, so that they eat poisonous plants, which ordinarily would be left untouched, in sufficient quantities to cause loss. Sheep exercise the greatest possible choice in their grazing when allowed to graze openly and quietly. So long as the stomach of any ruminant is empty, it is restless and anxious to move. Therefore, in the morning, when the animals commence to graze, they

Figure 7—Heavy winter losses were prevented on this winter range last year by the use of concentrate in the form of cotton-seed cake

eat many plants which are apparently palatable, but which in the afternoon and evening they seldom touch. So the palatability of plants not only varies with different animals and different ranges and grazing types, but also at various periods of the day and the grazing season. Thus it is apparent that, in order to reduce losses to a minimum, stock, especially sheep, should have as much freedom as possible.

There is greater chance for poisoning in large flocks of 2,000 to 2,500 than when the band limit is maintained at from 1,200 to 1,500 head. This is due to the fact that it takes the larger bands longer to spread out and it is much harder to allow them to graze openly and quietly. Consequently they have to be in a much more compact flock. This forces the sheep on the inside of the flock and the trailers to eat many obnoxious plants, or plants which under normal conditions would be unpalatable. Thus losses from poisonous plants are often caused by herding in too large bands.

Many sheep are poisoned on the range simply because of the laziness, carelessness, and irresponsible conduct of the herders. There is a vast difference in the way various herders handle their flocks. The lazy irresponsible herder resorts to the unreasonable use of his dogs, herding from the tail end and keeping the flock most of the time in a compact mass. The efficient herder seldom uses his dogs, but allows the animals to graze at all times just as openly and quietly as possible; and, instead of herding from the rear, he is continually turning the leaders so that the rear of the flock is as open as the lead.

All observations tend to show that, in order to reduce loss from poisonous plants to a minimum, the following rules should be adhered to as closely as possible:

1. Keep the band limit low; 1,200 head in a flock is the ideal number.
2. Allow the animals to graze as quietly and openly as possible.
3. Never turn stock upon a strange range without first making certain that it is free from poisonous plants.
4. After shipping, it is always best if possible to fill the animals with hay, for this will ordinarily prevent loss from bloat or poisonous plants.
5. Never trail over an area infested with poisonous plants unless the stomachs of the animals are full.
6. Salt regularly and abundantly.
7. Allow the animals to go as leisurely as possible over areas where poisonous plants exist.
8. If possible, try to herd the stock away from all areas infested with poisonous plants.

Methods of handling so as to avoid range losses are being developed for each of Nevada's poisonous plants, but as yet these data are far from being complete and definite.

PROJECT 7—REESTABLISHMENT OF NATIVE RANGE FORAGE PLANTS

All of the extensive range investigations tend to show that the only plants which will grow on the semiarid range of the West are the natives, or the plants which through years of extreme competition have thoroughly adapted themselves to meet the desert-like conditions. The introduction of new plants has resulted in failure so far wherever tried. There may be a few plants in the world that will grow on the western ranges other than the natives, but they have not yet been found. To try to reseed artificially would be very difficult on account of (1) the vastness of the area; (2) seed of native forage plants cannot be had in sufficient quantity at any price, much less at one which would permit their being broadcasted on the land; (3) reseeding operations, using any sort of stirring of the soil, are expensive and out of all proportion to advantage gained; (4) seeds of cultivated forage crops, which can be had in sufficient quantity, are not adapted to grow under the dry conditions found on the western ranges.

It is, therefore, evident at the present time that the most feasible way of revegetating the range is by natural reseeding, and not by the introduction and substitution of grasses other than those naturally found growing on the western range. The improvement that we may expect from natural reseeding under proper range management may be expressed in increased carrying capacity from 20 to 100% over what it is now.

In order to bring about a condition of natural revegetation over all of the range, it will require:

1. Federal legislation in order to provide range control;
2. Investigations for each of the principal forage plants making up the various grazing types as to—
   - (1) time when plant growth commences and ceases;
   - (2) time of flowering;
   - (3) time of seed dissemination;
   - (4) amount of seed produced;
   - (5) viability of seed produced;
   - (6) all other factors influencing the natural reseeding and establishment of the plant;
   - (7) comparative study of reproduction under—
     - (a) complete protection;
     - (b) existing grazing practises;
     - (c) grazing after seed maturity.

Figure 8—Typical White Sage Range. This type of range supplies the greater bulk of the winter sheep feed and is becoming depleted at an alarming rate.

In order properly to collect all of these data, it will be necessary to have a large area of public domain range set aside purely for investigative purposes. Under existing grazing conditions on the public domain only general observations can be made. It is hoped that in the very near future such an area will be available for the study of the reestablishment of the native forage plants on Nevada's depleted grazing ranges. Several areas have been tentatively selected, but as yet it is not deemed advisable to ask to have them set aside as experimental range reserves.

PROJECT 8—RELATIVE IMPORTANCE OF NATIVE RANGE FORAGE PLANTS

In order to handle most efficiently the public domain range, it is necessary to have a thorough knowledge of the vegetation which makes up the forage crop. This knowledge for each plant must include:

1. Time when plant growth begins and ends;
2. Flowering period;
3. Seed dissemination;
4. Grazing type in which found growing;
5. Relative abundance in each grazing type;
6. Feeding value;
7. Palatability to the various classes of live stock.

The practical application of the above data is to show (1) classes of stock to which each range is best adapted; (2) proper seasons of grazing; (3) carrying capacity of the range; and (4) systems of range management which should be used in order to secure the greatest possible use of the range with the least loss of forage through nonuse.

We plan to collect these data under three headings: (1) grasses; (2) weeds; (3) shrubs. Due to the very arid climate, the place that the grasslike plants or sedges have on the ranges in this State is negligible. Economic data have been collected for twenty-one different plants, but it covers a period of only one year. It will take several more years before these data are of a definite and tangible nature.

PROJECT 9—INTRODUCTION OF FOREIGN RANGE FORAGE PLANTS

This study at the present time merely contemplates the introduction of range forage plants found growing on similar dry ranges in the West, but not found on the ranges in Nevada. Due to lack of time, no plant introductions have as yet been made, and this study will be subordinated until the more important projects are put on a firm working basis.

PROJECT 10—CARRYING CAPACITY OF THE RANGE

So far only data for sheep have been collected, tending to show the average acreage required to support a sheep for a given period of time. The observations were made on summer grazing ranges. During the winter of 1917–1918 definite winter grazing carrying capacity figures will be collected for the winter ranges of the State. Carrying capacity tests for cattle have not been commenced. As soon as suitable conditions are available, such tests will be initiated.

The carrying capacity tests so far indicate that the average acreage required per sheep per 100 days, counting two lambs equal to one ewe, is 1.82 acres. These observations were made on a range where plant composition was made up largely of grasses and weeds, with a scattering growth of browse.

PROJECT 20—WHITE SAGE STUDIES

The white sage (*Eurotia lanata*) is one of the most important plants found growing on the grazing ranges of Nevada. During the winter time it supplies the greater bulk of the grazing for sheep. Practically all of the white sage is found on public domain range. The grazing season during which it is utilized varies, but it ordinarily commences during November and ceases in April and May. The entire plant is of such a nature that practically all of it above the ground is removed during grazing. It has a rather large and extensive root system, so that it is capable of storing much reserve food material.

However, due to excessive grazing, hoofing and grazing too late in the spring, this plant is rapidly being weakened and killed out. There are now large areas where only dead plants remain of what was once

a range with a high carrying capacity. On many ranges most of the plant crowns are practically dead, with only a few remaining live shoots left. It grows usually in a very light-colored soil, apparently high in lime. It is highly relished by all classes of stock, but is essentially a sheep feed. The greatest damage is being done by repeated grazing,

Figure 9—White sage ranch properly grazed during winter, which will produce an abundance of feed for the next year.

Figure 10—White sage range after severe winter grazing. Only the crowns are left supporting a few bare stems.

not only by the same flock of sheep but by different flocks drifting from one range to another. This late grazing is particularly harmful in the spring of the year when plant growth has commenced, after having been severely grazed during the winter. Just as soon as the young

shoots are produced, mainly from the reserve food supply in the roots, they are grazed off and as a result the plant is materially weakened. This type of grazing is destructive to the plant when it takes place year after year, and this is what is occurring on the white sage ranges of Nevada.

Through the courtesy of the United States Indian Service, a tract of white sage land has been allotted to the Experiment Station for experimental purposes. A part of this area will be fenced. Between 60,000 and 100,000 head of sheep winter in the vicinity of this white sage area. It is, therefore, an ideal location upon which to study the complete biology of the white sage and to supplement the intensive observations by the actual grazing by sheep on a large scale on the white sage range.

On the white sage winter range south of Elko last winter the grazing was supplemented by the feeding of cotton-seed cake. The general conclusions from these feeding operations are:

1. It is profitable and desirable to supplement the white sage with some form of concentrate;
2. It keeps the digestive system in excellent condition, thereby keeping the animal in a healthy, thrifty state;
3. It prevents loss from actual starvation during severe storms;
4. It keeps the mouths from becoming sore, thus preventing starvation losses due to sore mouths.
5. The ewes are in good condition at lambing time, which insures the safety of both the ewe and the lamb;
6. It keeps yearlings and two-year-olds in growing condition.

The costs and definite results of the feeding tests will be available at a later date.

In connection with the carrying capacity tests, data were collected last summer as to the best methods of handling sheep so as to (1) reduce the waste of range forage, due to trampling, to a minimum; (2) the production of the largest range lamb possible; and (3) to increase the carrying capacity of the range. Eight flocks of sheep were under observation; five were herded under the old existing method of returning to a permanent bed-ground each night; and three were allowed to bed where night overtook them. The general results were a saving of from 10 to 20 per cent in the acreage of range required, depending upon the efficiency of the herder; and an increase of from four to seven and one-half pounds in the weight of the lambs, when the sheep were allowed to bed where night overtook them and to graze at all times just as quietly and openly as possible. The methods of herding, bedding, salting, method of field reconnaissance and lamb weights, will be given in detail at a later date.

PUBLICATIONS OF THE STATION FOR THE FISCAL YEAR 1916-1917

Bulletins and Reports.

No. 84—"Contagious Epithelioma in Chickens (Chicken-Pox, Swelled Head): Its Control by Vaccination," by Winfred B. Mack, D.V.M., Veterinarian and Bacteriologist, and Edward Records, V.M.D., Assistant Bacteriologist. April, 1916.

No. 85—"The Use of Bacterins in the Control of Fowl Cholera," by Winfred B. Mack, D.V.M., and Edward Records, V.M.D. December, 1916.

No. 86—"Forage and Root Crops," by C. S. Knight, B.S., Dean of College of Agriculture, and Agronomist of the Agricultural Experiment Station. April, 1917.

No. 87—"Home Potato Patches," by C. S. Knight, B.S., Dean of College of Agriculture, and Agronomist of the Agricultural Experiment Station. April, 1917.

No. 88—"Field Crops for Late Planting," by C. S. Knight, B.S., Dean of the College of Agriculture, and Agronomist of the Agricultural Experiment Station. April, 1917.

No. 89—"Grain Production in Nevada," by C. S. Knight, B.S., Dean of the College of Agriculture, and Agronomist of the Agricultural Experiment Station. April, 1917.

Annual Report of the Board of Control for the Fiscal Year ending June 30, 1916. Published by the University of Nevada, Reno, Nevada.

Technical Papers, Contributions to Farm Journals, Etc.

"Industrial Preparedness for Peace," by Dr. C. A. Jacobson. Scientific American, Vol. 115, p. 80, July, 1916.

"Sheep Poisoned by Western Golden-Rod (*Solidago spectabilis*)," by Stephen Lockett. Journal of American Veterinary Medical Association, Vol. LI, N. S. Vol. IV, No. 2, pp. 214-221, May, 1917.

"Agriculture in Nevada," by Dean C. S. Knight. Rural World, October 27, 1917.

FINANCIAL STATEMENT

C. H. Gorman

Nevada Agricultural Experiment Station

IN ACCOUNT WITH

The United States Appropriations, 1916–1917

Items	Abstract	Hatch Fund	Adams Fund
Debit			
To balance from appropriations for 1915–1916		$0.00	$0.00
Receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1917, under Acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund)		15,000.00	15,000.00
Credit			
By salaries	1	$9,106.55	$9,015.46
By labor	2	1,974.27	2,286.48
By publications	3	433.82	
By postage and stationery	4	293.99	116.16
By freight and express	5	79.15	49.38
By heat, light, water, and power	6	149.70	168.32
By chemicals and laboratory supplies	7	224.39	69.97
By seeds, plants, and sundry supplies	8	249.10	283.31
By fertilizers	9	None	None
By feeding stuffs	10	221.98	1,045.42
By library	11	173.11	21.65
By tools, machinery, and appliances	12	672.52	481.68
By furniture and fixtures	13	16.10	1.05
By scientific apparatus and specimens	14	13.55	256.62
By live stock	15	115.20	1,049.88
By traveling expenses	16	592.96	186.62
By contingent expenses	17	21.60	None
By buildings and land	18	662.06	18.00
By balance		0.00	0.00
Totals		$15,000.00	$15,000.00

We, the undersigned, duly appointed Finance Committee of the Corporation, do hereby certify that we have examined the books and accounts of the Nevada Agricultural Experiment Station for the fiscal year ended June 30, 1917; that we have found the same well kept and classified as above; that the balance brought forward from the preceding year was $0 on the Hatch Fund and $0 on the Adams Fund; that the receipts for the year from the Treasurer of the United States were $15,000 under the Act of Congress of March 2, 1887, and $15,000 under the Act of Congress of March 16, 1906, and the corresponding disbursements $15,000 and $15,000; for all of which proper vouchers are on file and have been by us examined and found correct, leaving balances of $0 and $0.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said Acts, respectively.

(Signed) EDNA C. BAKER,
J. W. O'BRIEN,
Finance Committee Board of Regents.

[SEAL]

Attest: (Signed) C. H. Gorman, *Custodian.*

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AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Annual Report of the Board of Control for the Fiscal Year Ending June 30, 1918

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

CARSON CITY, NEVADA
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
1919

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NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

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Charles S. Knight, B.S.	Agronomist
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Hester Mayotte	Secretary to Director

FINANCIAL STATEMENT

By C. H. Gorman

Nevada Agricultural Experiment Station

IN ACCOUNT WITH

The United States Appropriations, 1917–1918

Items		Hatch Fund	Adams Fund
Debit			
To balance from appropriations for 1916–1917		$0.00	$0.00
Receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1918, under Acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund)		15,000.00	15,000.00
Credit	Abstract		
By salaries	1	$8,892.64	$9,789.13
By labor	2	1,869.10	734.95
By publications	3	568.89	
By postage and stationery	4	401.24	24.63
By freight and express	5	155.40	72.77
By heat, light, water and power	6	158.40	23.10
By chemicals and laboratory supplies	7	368.47	372.67
By seeds, plants and sundry supplies	8	309.81	261.27
By fertilizers	9	0.00	0.00
By feeding stuffs	10	177.82	1,248.04
By library	11	65.70	5.75
By tools, machinery and appliances	12	243.74	258.22
By furniture and fixtures	13	575.98	20.65
By scientific apparatus and specimens	14	2.38	46.67
By live stock	15	30.00	1,562.46
By traveling expenses	16	697.28	306.65
By contingent expenses	17	25.00	0.00
By buildings and land	18	458.15	273.04
By balance		0.00	0.00
Total		$15,000.00	$15,000.00

We, the undersigned, duly appointed Finance Committee of the Corporation, do hereby certify that we have examined the books and accounts of the Nevada Agricultural Experiment Station for the fiscal year ended June 30, 1918; that we have found the same well kept and classified as above; that the balance brought forward from the preceding year was $0 on the Hatch Fund and $0 on the Adams Fund; that the receipts for the year from the Treasurer of the United States were $15,000 under the Act of Congress of March 2, 1887, and $15,000 under the Act of Congress of March 16, 1906, and the corresponding disbursements $15,000 and $15,000; for all of which proper vouchers are on file and have been by us examined and found correct; leaving a balance of $0.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said Acts, respectively.

(Signed) EDNA C. BAKER,
J. W. O'BRIEN,
Finance Committee.

[SEAL]

Attest: C. H. Gorman, *Custodian.*

WINFRED BERDELL MACK

Born March 22, 1872
Died January 18, 1918

Winfred Berdell Mack was born on March 22, 1872, at Vermillion, State of New York. He received his early education in the public and high schools of Mexico, New York, and after graduation taught in the district schools for a few years. He then took up a business and commercial career for a number of years, which developed in him a rare knowledge and judgment of men which was useful to him later in his profession.

Having obtained the business experience he wanted, he decided that he needed a college education and that his real interests were in science. From the time he began as a Freshman, his associates marked him out as an exceptional student of rare scientific ability. He graduated from the New York State Veterinary College of Cornell University with the degree of D.V.M. While in Cornell, he held a fellowship in bacteriology and assisted in teaching several courses. Dr. Soper of New York City, who directed the investigation of the Ithaca typhoid epidemic of 1903, was assisted in this work by Dr. Mack, and especially commended his work.

In 1899, Dr. Mack was married to Miss Olla M. Symonds of Fulton, New York.

In 1906, Dr. Mack came to Nevada as the head of the newly established Department of Veterinary Science and Bacteriology. In the eleven years of his service to the University and State, the Department has grown and extended its activities so that it now numbers four scientific investigators, with laboratory and office assistants, and keeps in touch with the animal diseases of the entire State. Besides directing the scientific researches of the laboratory, Dr. Mack was at the time of his death Director of the State Veterinary Control Service, ex officio State Quarantine Officer, Secretary of the State Board of Stock Commissioners, and ex officio member and Secretary of the State Rabies Commission.

Dr. Mack's whole life was wrapped up in his work and he exhausted his energy in order that no call for service might go unanswered. Up to a few weeks before his death, even when confined to his bed, he directed the work of his department as usual. The results of the various investigations are embodied in a number of valuable scientific reports and bulletins.

He was Resident Secretary for Nevada of the American Veterinary Medical Association and was also a member of the Society of American Bacteriologists and of the United States Live Stock Sanitary Association. He belonged to the honorary societies of Sigma Psi and Phi Kappa Phi. In addition to his professional work, he was also a director of the Union Building and Loan Association, and took an active interest in public and state affairs.

PETER FRANDSEN,
EDWARD RECORDS.

LIST OF ACTIVE PROJECTS, 1918–1919

Project 1. Irrigation Experiments. (Hatch Fund.) 1914–1919. Project Leader, C. S. Knight.

The purpose of these experiments has been to determine the amount of water needed for the production of various crops. It is evident that in many portions of Nevada too much water is used where water is abundant, and it is equally evident that in other portions of the State a short supply of water is used somewhat unwisely. There are stages in the growth of every plant at which water is especially necessary. In this project it is Dean Knight's purpose to find out at what stage of growth water is most essential and to find out how many irrigations and what quantity of water will produce the best results with grain crops, potatoes, and alfalfa. The fact that during the past five years the summer rainfall has been scanty has made it possible to obtain results which were not in any way confused by rain; that is, differences in crop yields under this experiment have been due entirely to differences in the amount of water supplied and in the time of application.

Project 2. Variety Testing and Crop Improvement. (Hatch Fund.) 1914–Continuous. Project Leader, C. S. Knight.

Under this project, Dean Knight studies varieties of grain, alfalfa, potatoes, and other crops which are best suited to Nevada soils and climate.

Project 25. Methods of Increasing Hay Production in the Humboldt Valley, Nevada. (Hatch Fund.) 1919–1924. Project Leader, C. S. Knight.

For some years it has been evident that in the Humboldt Valley the yield of hay has been less than it should be because of the methods of irrigation employed. It is the purpose of this project to show the effect of different methods of irrigation upon crop yields and to show how a better quality and greater quantity of hay may be obtained in the Humboldt Valley by a change in the methods of irrigation. This project will be fully outlined in the spring of 1919. The work will be carried on in cooperation with the Bureau of Public Roads and Rural Engineering, United States Department of Agriculture. The department has assigned an engineer, Mr. F. L. Bixby, to this project.

Project 5. Insects Injurious to Alfalfa. (Hatch Fund.) 1916–Continuous. Project Leader, S. B. Doten.

This project is a study of grasshoppers, cutworms, and other insects which attack alfalfa in Nevada.

Project 23. Revegetation of Depleted Ranges. (Hatch Fund.) 1916–Continuous. Project Leader C. E. Fleming.

Under this project, studies of Nevada range conditions have shown that many Nevada ranges on the public domain are nearly ruined and that on others the carrying capacity is steadily falling off. It has become clear, moreover, that little or nothing can be done on the open

public-domain ranges to improve conditions. On ranges privately held or held under the control of the United States Forest Service, an improvement in range pasturage is easily brought about by adapting the method of handling sheep and cattle to the habits of growth of the plants and grasses on which these animals feed.

Project 24. Methods of Increasing the Percentage of Lambs in Nevada Flocks. (Hatch Fund.) 1919–1921. Project Leader, C. E. Fleming.

This project is a study of methods of feeding ewes in the winter and spring for the purpose of increasing the percentage of healthy lambs in Nevada flocks.

Project 15. Equine Anemia. (Adams Fund.) 1908–Continuous. Project Leader, Dr. Edward Records.

This is a study of a common disease of horses in Nevada. As equine anemia appears to be always present, although varying in amount from year to year, and as losses caused by it are important, the disease has been kept continually under study for a long period both in Nevada and in adjacent States. The work has been exceedingly difficult and baffling, and no definite results have yet been obtained. These studies are, however, to be continued in the hope that in the long run they will lead up to methods of control.

Project 16. Hemorrhagic Disease in Cattle. (Adams Fund.) 1914–Continuous. Project Leader, Dr. Edward Records.

This disease is one which has not been completely diagnosed either in Nevada or in any adjoining State where it occurs. The cause of the complaint is unknown, although the conditions under which it is most apt to occur have been observed, Still, without definite knowledge of the cause of the disease, important progress has been made toward its control. It is hoped that a few years more of study may clear the entire matter up and make it possible both to prevent the disease and to cure it after it has occurred.

Project 18. Contagious Epithelioma in Fowls. 1914 (Hatch Fund); 1916 (Adams Fund). Project Leader, Dr. Edward Records.

Heavy losses are sometimes caused by "roup" or contagious epithelioma in fowls in Nevada. Methods of control have been worked out and it is hoped so to perfect them that under proper treatment epidemics may be immediately checked.

Project 19. Biting-Flies of Cattle. (Adams Fund.) 1916–1921. Project Leaders, J. L. Webb, United States Department of Agriculture, and S. B. Doten, Nevada Station.

This project is a study of biting-flies which cause serious annoyance and even considerable loss in the livestock industry in certain portions of Nevada. The habits of the flies have been worked out; their breeding places have been determined, and it is hoped that in a general way it may be possible to show methods by which these insects can be controlled. The work is done as a cooperative project shared equally between the Nevada Station and the United States Department of Agriculture, whose Bureau of Entomology detailed a man to undertake the work on a cooperative basis.

Project 20. White Sage Studies. (Adams Fund.) 1916–Continuous. Project Leader, C. E. Fleming.

The present condition of the winter range in Nevada has caused anxiety among sheep and cattle owners, at whose request a study of the white sage was undertaken in the hope that methods of preventing further injury to white-sage ranges might be worked out.

Project 22. Poisonous Range Plants. (Adams Fund) 1916; (Hatch Fund) 1918–Continuous. Project Leader, C. E. Fleming.

This project is a study of a large number of poisonous plants found on Nevada ranges for sheep and cattle. The purpose of the project is to determine in the first place which plants are poisonous and how great a quantity of the plant is required to produce fatal poisoning. Methods of handling sheep and cattle on the range in such a way that poisoning will be less likely to occur are being worked out, together with methods of destroying certain plants which may be locally exterminated.

ADMINISTRATION

THE RELATION OF THE AGRICULTURAL EXPERIMENT STATION TO THE STATE

Science in the Experiment Station.

In the section on Administration in the Annual Report of the Nevada Station for the fiscal year ending June 30, 1914, the scientific basis of station work was fully discussed and also the type of organization required to maintain the distinction between research work and extension and demonstration. Emphasis was placed on the fact that the work of an experiment station must conform to a standard of scientific investigation founded on the world's experience in research; and that conditions in the station must favor the scientific spirit.

Conditions in a state university and in the station which is a part of the larger organization must favor the scientific spirit—the spirit which seeks the truth and bases its conclusions on evidence. Yet the scientific standard alone is not sufficient. Truly, it enables us to judge the accuracy of conclusions and to determine their relation to facts previously known. Still, painstaking accuracy of method and logical completeness of plan alone give no safe guide, no standard for judging the local suitability of any proposed piece of work or its advisability. That is, it would be possible for a station to do work of irreproachable scientific character and yet to have much of its activity lie outside its own proper field. Another standard is needed.

By what standard shall we decide upon the relative amount of support to be given to different departments in the station? How are we to decide upon the sums to be allotted to various projects? Why grant perhaps twice as much to one station project as another? Shall we base our decisions upon the scientific training of the men, or upon the scientific character of their proposed work, or upon the care and accuracy of the plan for work presented, or its detailed completeness? Only in part.

The standard required in the intelligent allotment of money to various departments and projects of the station is found in the standard of public service and in the nature of the experiment station as a public-service institution.

Aid to Industry.

Agricultural experiment stations were founded in the various States in order that they might be of assistance to agriculture in each of these States. The purpose of the American experiment station is to solve by scientific methods the problems of the local agricultural industry. This is what may fairly be expected of them by the people of the States in which they are located. And in setting up a standard by which to judge projects and lines of work in the stations, this purpose must be kept constantly in mind. The relation of the stations to the industry for whose benefit they were founded may be stated in the following terms:

(1) The agricultural experiment stations were founded to aid an industry—agriculture.
(2) Their basis is economic.
(3) Their function is to obtain information of use in the solution of agricultural problems.
(4) Their method is scientific.

All that we have said earlier about the importance of the scientific method has been said because of the necessity of getting indisputable evidence on which to base safe conclusions. The scientific method is merely a logical, sensible method of basing safe conclusions upon carefully tested evidence. Still, on method alone no lasting station policy can possibly be founded. If, in enthusiasm for the scientific method, or in a zeal for making contributions to the sciences, we lost sight of the economic relation and purpose of the stations we may readily reach a point where funds are allotted because of the scientific character of the work and its possible contribution to science, rather than because the work is vitally needed for the solution of agricultural problems.

The project in the station is on safe ground when it represents an attempt to solve by scientific methods some problem in an agricultural industry. The simple thing, the obvious thing, is to determine first of all what are the problems of the agricultural industry to which the scientific method of solution is to be applied.

Finding the Field for Work.

It is an interesting thing to imagine how we would begin experiment station work in a part of the United States where such work has never before been done. What would be our lines of work and what our projects? What departments would we establish? First of all in such a case, we would make a careful study of local agricultural conditions in order to find the leading problems; after discovering these problems, we would be in a position to decide what sciences were needed for their solution. In most of the States the problems would fall into large groups corresponding to the agriculture of the region, as determined by soil, climate, and markets.

For example, in a region with a large livestock industry we would immediately discover groups of problems in feeds and feeding and in animal diseases. If the feeding problems seemed of primary importance, we would then plan long series of feeding tests and we would establish in the new station a department of animal husbandry. If the problems of animal disease were of fundamental importance, we would organize a department of bacteriology and veterinary science.

In a fruit-raising region, we would probably establish first of all a strong department of horticulture. Departments would be organized for the study of insect pests and plant diseases, corresponding to the department of animal diseases in a cattle-raising State. That is, from the very beginning the departments and projects of the experiment station would represent vital problems of the State's agriculture.

Science Because of Its Usefulness.

The scientific method would be insisted upon and most carefully guarded. From the beginning every effort would be made to maintain in the new station the scientific spirit, even in the simplest and most elementary problems; but this would be done not for the sake of making contributions to the sciences, but for the sake of the practical use-

fulness of the scientific method in obtaining facts based upon genuine evidence. However, the standard of judgment by which the relative importance of departments and of projects would be determined would still be not the scientific character of the work, nor the relative scientific character and training of the men, but the nature of the problem, its importance to agriculture, and the permanence of the need for its investigation.

Upon this standard of essential service the station would found its experimental and investigational work, and this standard would determine the departmental organization; the equipment and personnel of the departments and year by year the nature of the annual allotments of funds. Only by close adherence to this standard through the years could the station be maintained in a state of flexibility, ready to meet needs as they might arise and to give the most useful service to the local farming industry.

Reorganization of the Nevada Station.

In the course of the past five years the Nevada Agricultural Experiment Station has been completely reorganized. The movement began under the directorship of Professor Gordon H. True, who resigned at the end of his first year's service as Director to accept a more lucrative position in his own field of special training in the University of California. Professor True showed a clear understanding of the nature of experiment station work and began the reshaping of the work of the Nevada Station along lines of more helpful public service. Mr. True realized that an experiment station was founded under federal funds in each of the States in order that it might give direct assistance to the agriculture of that State in the solution of its vital problems. From this point of view it is evident that the personal enthusiasm and interest of members of the Station Staff must be subordinated, in the spirit of public service, to well-disciplined work for the good of the agricultural industry.

Upon the present Director, in the fiscal year 1913-1914, fell the responsibility of developing the organization and policy of the Nevada Agricultural Experiment Station. From the beginning the reorganization has been supported and encouraged by the President and the Board of Regents of the University. They have aided the present Director in every way in the development of projects which promise assistance to Nevada agriculture.

If the peculiar conditions found in Nevada and the problems presented by our agriculture are taken as the basis of our studies, then the work of the Nevada Station must be based upon three great groups of problems—the water problems, problems of animal disease, and range problems.

The Water Problems.

First of all, the water problems are exceedingly important. The immense acreage of good land in Nevada is good land only as water makes is so. In favorable years in certain parts of the State dry-farming is successful, but, taking the State as a whole, its success is doubtful. The fundamental farming problem in Nevada, based on immense acreage, scanty rainfall and a totally inadequate supply of water for irrigation, is this: How can we gain the greatest yield per acre-foot of water? In Nevada it is not a question of the maximum

crop per acre of land. It is a question of the greatest crop value per inch of water. Here is a legitimate field for investigation and experimental work, the study of methods of making our small available water supply yield as heavily as possible.

One of the first things done, then, in the reorganization of the Nevada Station, was to establish in 1913–1914 under C. S. Knight, Dean of the College of Agriculture, a study of the amount of water actually needed by the principal crops grown in Nevada and of the stages at which irrigation is most important, with the number of irrigations and the quantity of water actually required. These experiments have been continued for nearly five years, and the work has been done with skill and care and painstaking thoroughness.

Problems of Animal Disease.

The second great group of problems self-evident in Nevada agriculture are the problems of animal disease. By all odds the greatest export crop of the State is its annual output of sheep and cattle and their products. In the year 1917 the value of these products on ranches and farms was as follows:

Sheep	$11,931,000.00
Cattle	18,565,000.00

Of other agricultural crops the values were as follows:

Potatoes	$3,726,000.00
Hay	10,796,000.00
Apples	307,200.00
Wheat	2,052,000.00

It is easily seen from the above figures how the sheep and cattle industries overtop every other form of agriculture in this State. Nor is this merely a temporary condition. Truly, in very many of the other Western States the old range has been broken up into farms; and the livestock industry has almost vanished or has been very greatly changed. In Nevada this is not the case, and never can be; for most of the sheep-and-cattle ranges are hill ranges or mountain ranges, far too high and too steep for farming. In northern and central Nevada the valleys lie so far above sea-level that cool summer nights and a short growing season restrict the kinds of crops that may be grown. The irrigated mountain valleys, however, are admirably suited to the production of hay; and hay is needed for the winter feeding of range live stock. So, based upon a great sheep-and-cattle industry, we have ranches and farms where large quantities of grass hay and alfalfa hay are raised, ranch and range together forming the foundation of a permanent livestock industry.

Animal diseases are, of course, found in Nevada as elsewhere. With the growing cost of meat and a corresponding increase in the value of sheep and cattle, disease problems grow in importance. Therefore, one of the most important fields of public service for the Nevada Station is a study of such diseases. For this reason it has been as wise as it was important to expand considerably the Department of Veterinary Science and Bacteriology and to grant that department in the Station a personnel and equipment which would let it give to the livestock industry of Nevada a greatly needed scientific service.

This department has proven its usefulness, not only to the large

livestock owners, but to the small farmers as well. In districts dependent on the dairy industry and upon hog-raising and chicken-raising, problems of animal disease press heavily upon the small farmer. Under Nevada conditions the Agricultural Experiment Station is in a position to be of even greater assistance to the small farmer than to the large owner of live stock. The man who has thousands of head of cattle and sheep running at large on the public domain does not feel the loss of a number of animals as much as the small farmer with only a few head of stock and a restricted range. The strengthening of the Department of Veterinary Science and Bacteriology in the Experiment Station has met an instant response from the people of the State, who are quick to feel that in this department the University is giving the State an essential public service.

Range Problems.

The third large group of problems plainly evident in Nevada agriculture, are the problems of diminishing pasturage on summer and winter range. The effect of the overstocking of ranges, the gradual but sure disappearance of valuable grasses and forage plants from the open public domain, is evident throughout the whole West. Like other Western States, Nevada feels more and more every year the injurious effects of overgrazing, although local conditions have in many instances established control and prevented to some degree the most severe overstocking.

Ranch and range in Nevada are so closely tied together by economic conditions that in many portions of the State a ranch would be useless without its adjacent range. It is easy to find parts of Nevada where the favorable local climate and soil conditions make it possible to grow the finest celery, onions, apples, and other relatively high-priced products. Still, the land must be put into hay and kept in hay year after year because there is no local market for the other products and the expense of shipment to a distant market is prohibitive. Hay is needed for the cattle; and the land yields alfalfa and wild grasses abundantly. The hay would be of little or no value if it were not for the adjacent range. As it is, the hay is fed on the ranch and later the cattle are driven out for shipment.

For the study of range problems the Nevada Station established in 1915 a Department of Range Management, headed by C. E. Fleming, formerly in charge of the Jornada Grazing Reserve of the United States Forest Service. In the past two years this department has done admirable work in the study of poisonous range plants and other range problems.

General Policy of the Nevada Station.

In the reorganization of the Nevada Agricultural Experiment Station outlined in the last few pages, the first question asked was: "What are the leading agricultural problems of the State on which departments and projects in the Station should be based?" The answer is: "The principal problems are water problems, animal disease problems, and the range problems."

Still, the answer is, of course, incomplete in some particulars. There is a limited horticulture along the western border of Nevada. Potatoes are grown to some extent. There are certain spots where apples may be grown at a profit; then there is a rich fruit belt lying at a low

altitude along a tributary of the Colorado River below Moapa, Nevada; and, in various portions of the State, there are valleys where dry-farming is under trial. Still, on the whole, the three great groups of problems mentioned above are the leading ones, and it is in connection with these that most of the work of the Station is being done.

This does not mean, however, that our work is confined exclusively to these three problems. These three are always at hand; but problems of insect pests and plant diseases and other matters come up from time to time, and solutions must be sought if the Station is to give the fullest service. In brief, it is the policy of the Nevada Experiment Station to found its work upon the actual needs and problems of the State and to base its allotments to projects and departments upon the standard spoken of in preceding paragraphs, the standard of usefulness to the agricultural industry. At the same time every effort is made to maintain a high scientific standard in the work, for the simple reason that the most useful information is that which is securely founded upon unimpeachable evidence.

Based upon the needs and the problems of Nevada agriculture, the policy of the Station is impersonal. In the organization of departments and the development of projects the first principle is a recognition of the real needs and merits and problems of the State. Thus, the policy and the field of work in the Station are dependent, not so much on personality or opinion, as upon a sound judgment of problems and of methods for their solution. The field of work of the Station is determined by the State's agriculture. The projects of the Station are based on problems of agriculture. They are essentially independent of change in either administration or staff.

Close cooperation between the divisions of the Station is highly essential. Department heads working in the spirit of public service will often find themselves obliged to subordinate their own likes and dislikes and to limit their work severely to the actual needs and problems of our agriculture. This may be true, even at a time when the scientific interest attaching to a new discovery, or to lines of work readily possible may make the experimenter ardently anxious to carry his investigations afield into pure science.

The work of reorganization in the Nevada Station has received consistent support from the University administration and a most cordial approval on the part of the Office of Experiment Stations, Washington, D. C. In fact, it would have been very difficult without the assistance of Dr. E. W. Allen, Chief of that Office. Dr. Allen has insisted upon the redirection of the Station's activities; and at times when it seemed very difficult he has given most useful counsel and encouragement. To his initiative as well as to his support, a large share of credit for recent progress in the Nevada Station is undoubtedly due. As a direct result, because of the development of experiments and investigations which promise to be useful to the State, the Station itself is gaining steadily in the respect and support of its constituency.

REPORT OF THE DEPARTMENT OF ENTOMOLOGY

By S. B. Doten

Project 19. Adams Fund. Biting-Flies of Cattle.

This is a study of certain biting-flies which are abundant and injurious on cattle pastures in parts of Nevada and California. The flies cause the cattle to bunch up in the middle of the day instead of feeding. The constant annoyance causes them to fall off in weight or to remain at a standstill, instead of putting on flesh, although feeding on rich pasturage.

The purpose of this project is to learn the habits and breeding places of the flies, with their earlier stages of growth and development,

Figure 1. Insectary for the Study of Biting-Flies, Antelope Valley, Nevada and California.

in order to find out whether artificial methods of control are practical under the circumstances.

The work has been done jointly by the Bureau of Entomology of the United States Department of Agriculture and the Nevada Agricultural Experiment Station. In 1917 an insectary was constructed at Topaz in Antelope Valley for the study of the flies in the midst of an infested region. Mr. J. L. Webb of the United States Bureau of Entomology was assigned to the project. He has been assisted by two young men from the University of Nevada, Mr. Rufus Ogilvie (1917) and Mr. Noble Waite (1918).

In the last two seasons it has become evident that while a number of different kinds of biting-flies are troublesome in the region under study, most of the annoyance and injury is caused by a single species,

a horse-fly of medium size, *Tabanus phænops*. The males do not bite; but the females obtain a part of their food from the blood of cattle and horses.

During the late afternoon and early morning hours the females rest in dry grass or in other concealed situations, feeding only during the brighter and hotter hours of the day.

Mr. Webb has worked out the life-history of this fly almost completely and has found that the eggs are laid on short grass over swampy meadow lands; that the maggots drop from the eggs to the mud of these meadows where they live and grow for two or more years until mature. The life-histories of the other flies which cause annoyance in the region have been partially worked out. In the course of the coming summer all these studies will probably be completed.

In the summer of 1919 this project will be terminated and the results

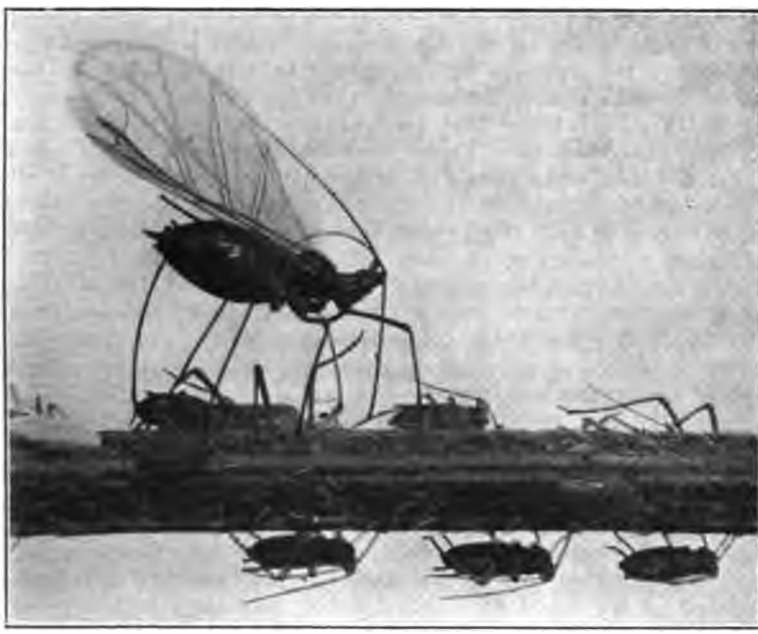

Figure 2. Plant-lice on Alfalfa. Macrosiphum creelii. Living specimens magnified ten diameters; that is, one hundred times natural size.

will be published later as a joint bulletin of the United States Bureau of Entomology and the Nevada Agricultural Experiment Station.

There is no indication that the introduction of parasitic insects will be of value in controlling this pest; nor does it seem at all probable that practical methods of artificial control will be discovered. Apparently the only thing which will bring about any great change in the biting-fly situation will be a change from ranching to farming. The breaking up and drainage of the great areas of wild-grass meadow and swamp lands, together with the changes brought about by raising grain and alfalfa, will establish soil and water conditions under which apparently the biting-fly maggots will not thrive.

The general economic situation promises to bring about such changes in the near future. The rising value of land makes it scarcely profitable to leave rich soil in an undrained, half-swampy and unproductive condition. Apparently just as soon as the wet meadows are drained and broken up and planted to grain or alfalfa, conditions will be established which will not favor the breeding of biting-flies. This conclusion will be carefully tested another year by a study of the reclaimed portions of Antelope Valley, to determine whether the flies under study do breed at all in alfalfa fields or along properly constructed laterals and drain ditches.

The Bureau of Entomology of the United States Department of Agriculture is certainly entitled to credit for the patience and persistence with which its representative, Mr. J. L. Webb, has successfully studied this unusually difficult problem.

Project 5. Hatch Fund. Insects Injurious to Alfalfa.

The Alfalfa Plant-Louse, *Macrosiphum creelii*. This small green plant-louse often appears in the spring in alfalfa fields in various parts of Nevada. It is frequently abundant enough to retard seriously the growth of the first crop of hay, especially when weather conditions are favorable. Under such conditions the alfalfa is short and stunted, not more than two or three inches high when it should be twelve inches or more. The leaves are gummed up with the clear, sticky honey-dew excreted by the insects, and every stem is covered with a mass of plant-lice.

Under these conditions, although seriously checked, the alfalfa may make a fair first crop or even a good stand, maturing later than the hay in the uninfested fields. The stickiness of the honey-dew causes the mower blades to gum up in cutting; and this is an additional source of annoyance and loss.

Apparently this insect is widely distributed in western America. frequently causing considerable losses. Present conditions on the ranges for sheep and cattle in Nevada and throughout the West make any injury to the hay crops especially important.

Very little is known about the life-history and habits of this plant-louse. For this reason it is probable that in the near future a detailed study of the matter will be undertaken. An insectary will probably be erected in the midst of infested fields; and the life-history of the pest will be worked out.

REPORT OF THE DEPARTMENT OF AGRONOMY

By C. S. Knight

PROJECT 1—IRRIGATION EXPERIMENTS

Irrigation Experiment with Alfalfa, Potatoes, and Wheat

The object of this investigation was to determine the critical stages in the irrigation of each crop and to show at what stages of growth the plants are best able to be deprived of an application of water without causing serious injury to the crops; also to determine the amount of water required for the greatest production, and the production with small applications at different stages. With potatoes and alfalfa a comparative study was made of the plants at different stages of growth with different methods of irrigation to determine the proper stages to irrigate these crops, and the proper amount of water to use at each application for the best results. With wheat the object was to determine at which stage or stages of growth an application of water may be eliminated without greatly affecting the yield of grain, and to determine whether or not two applications of water prove as effective as three or more applications with the same amount of water used.

Irrigation Investigations with Alfalfa, 1915-1917

During the three-year period, 1915–1917, experiments were conducted in the irrigation of alfalfa to compare the water content of the plant, the proportion of leaves to stems, the yield per acre and the yield per acre-foot of water, when irrigated with different depths of water and at different stages of wilting.

In these experiments the water was measured into the plats through two-inch galvanized iron pipes; and check plats were used to eliminate as far as possible the effect of variations in soil. The alfalfa was irrigated by the border method of flooding, using small furrows about three feet apart to provide a more ready channel for the water to the lower end of the plats. The head of water was so regulated as to prevent any run-off. The results herein recorded are, therefore, based upon the actual water used by the plats under the varying conditions presented.

When to Irrigate Alfalfa

A too common practice of irrigating alfalfa in Nevada is to apply water to the crop at regular intervals with little regard to the actual needs of the crop for water or to a possible injury to the soil by excessive irrigation.

One of the chief objects of these experiments was to study various depths of irrigation at different stages of wilting to determine the effect on the yield per acre and the yield per acre-foot of water.

The tests indicate that for the most practical results alfalfa is best irrigated when the leaves have turned dark-green in color and have begun to droop, using 12-inch applications. Under these conditions, alfalfa produced an average of 5.18 tons per acre with 36 inches of water, thus giving a yield of 1.73 tons per acre-foot of water.

The use of 12-inch applications before the plants showed need of

water produced the highest yield of 6.63 tons per acre with 80 inches of water, which gave a yield of less than one ton per acre-foot of water.

The continuous use of needlessly heavy irrigations may cause serious injury to the soil by producing a water-logged condition or washing down the soluble plant-food below the reach of the feeding roots.

The soil on our test plats is a sandy clay with considerable capacity for holding water. On lighter soils more frequent lighter applications will be required to prevent the washing down of soluble plant food and a loss of water by percolation.

In these experiments alfalfa responded better than wheat or potatoes to heavy applications of water.

Amount of Water Applied

These results indicate that under normal soil conditions, in Nevada, the most desirable amount of water for alfalfa will vary between 35 and 48 inches. The crop did not use economically more than this amount. Also continuous excessive irrigation lowers the producing power of the land.

The most economical use of water was obtained with an average annual total irrigation of 36 inches with 12-inch applications. The highest yield was obtained with a total irrigation of from 6 to 7 feet of water in 12-inch applications, but was accompanied by a low yield per acre-foot of water and an inferior quality of hay, due to the large proportion of coarse stems to leaves.

The decrease in total depth of irrigation was accompanied by a corresponding decrease in the water content of the plant and in the yield per acre. There was, however, an increase in the proportion of leaves to stems and in the yield per acre-foot of water.

Relation of the Soil Moisture Content to the Time and Amount of Irrigations

In conducting these experiments on the irrigation of alfalfa soil samples were taken at regular intervals during the period of irrigation to determine the variations in moisture content in relation to the time of irrigation and the depth of each application.

An increase in soil moisture content at harvest was noted with the 6-inch application in the first two stages of wilting and with the 9-inch application in the first stage, due in part to the frequency of irrigation. The greatest increase occurred with the 9-inch application and a total irrigation of 63 inches.

The most uniform decrease in moisture content at harvest was found in plots where the alfalfa was not irrigated until the leaves turned dark-green and began to droop. Here the total irrigation and the yield per acre increased as the depth of application became greater, while the yield per acre-foot of water decreased.

The yields per acre with the 6- and 9-inch irrigations applied when the alfalfa had turned dark-green, but had not yet begun to wilt, compared with a 12-inch irrigation applied after wilting had begun, showed but little difference. Still a great decrease of 35.4 per cent in moisture content at harvest with the 12-inch application, together with the high yield per acre-foot of water show that this was the most practical and economical use of water of these three methods.

When the alfalfa was irrigated before it showed any need of water or just as soon as it began to turn dark, the results indicated that when the total irrigation exceeded an average of from three to four feet, the

soil moisture content at harvest increased, thus showing that the excess of water applied was not used by the alfalfa.

Results of Irrigation Investigations with Wheat

In these experiments all wheat plats were irrigated at two or more of the five stages of growth, including the five-leaf, boot, bloom, milk and dough stages. The plats were about one-tenth acre in size, thus making possible the planting, irrigation and harvesting of the crop under normal field conditions.

Best Results with 28 Inches of Water in Four Applications

In this experiment the best results were obtained with 28 inches of water in four applications, omitting the irrigation at the five-leaf stage. The average results shown above are strongly in favor of the 7-inch applications. Very little difference was noted in yield of wheat when irrigations were omitted at the milk and dough stages, respectively. The lowest yields with both 3-inch and 7-inch applications were found with irrigations omitted at the boot and bloom stages, respectively.

When 7-inch applications were given at each stage of growth, or a total of 35 inches of water, the yield was 32.8 bushels per acre, or about 4 per cent less than where only 28 inches of water were applied and the irrigation omitted at the five-leaf stage. This may be attributed to the greater development of root system, with the first irrigation omitted, and at the same time the plants did not suffer from lack of sufficient moisture before the irrigation at the boot stage.

Results with Three Applications

The results were also in favor of the 7-inch applications, although the variations in yield were much more pronounced. The highest yield of 32.4 bushels per acre was obtained with 21 inches of water in three irrigations with applications omitted at the five-leaf and dough stages. The three lowest yields with 7-inch applications, averaging 21 bushels per acre, were obtained with irrigations omitted at the five-leaf and boot, bloom and milk, and boot and bloom stages, the last yield being 19.7 bushels per acre.

The low yields with both 3-inch and 7-inch applications when irrigations were omitted at the boot and bloom stages, indicate that the most critical period in the irrigation of wheat is between the boot and milk stages. When irrigations were omitted at the five-leaf and milk, and five-leaf and dough stages, very little difference was found in the yield, the average being 30.3 bushels per acre with 21 inches of water in three applications.

Yield per Acre-Foot of Water with Three and Four Irrigations and 7-inch Applications

It is interesting to note that where a total irrigation of 28 inches of water was given in four applications the highest yield per acre was accompanied by the highest yield per acre-foot of water, which showed conclusively that this was the most practical method presented for the irrigation of the wheat crop. The lowest yield per acre-foot of water was obtained with 35 inches of water in five 7-inch applications.

Results with Two Irrigations

Where only two irrigations were possible the two 9-inch applications, one before and one after heading, gave the largest yield, 31 bushels per

acre, or 10 per cent less than the highest yield with 28 inches of water in four applications. Apparently a 12-inch irrigation before heading provided more water than the crop utilized to the best advantage. The maximum yield with two irrigations was obtained with a total of 18 inches of water applied when the crop turned dark-green in color. With a total irrigation of less than 18 inches the yield was considerably decreased; whereas a total irrigation of 24 inches in two 12-inch applications produced an average of 28.2 bushels per acre or about 10 per cent less than where two 9-inch applications were used.

Yield per Acre-Foot of Water with Two Irrigations

The highest yield of 27.4 bushels per acre-foot of water was obtained with the smallest total irrigation of 12 inches, and the lowest yield of 14.1 bushels with the largest total irrigation of 24 inches. The second highest yield of 20.7 bushels per acre-foot of water was produced with the two 9-inch applications, which indicates that this is the most practical method presented to irrigate wheat when only two applications were given.

With only two irrigations the yields were generally lower throughout than with a greater number of applications using the same total amount of water. It is, therefore, recommended that only in cases of water shortage is it advisable to use only two irrigations, for with three or four applications our tests show that the yields of grain are generally much higher. It should be noted, however, that where only two irrigations are possible, a profitable crop of wheat can be grown.

Influence of Precipitation on Amount of Water Required

In many States where irrigation is practiced the annual precipitation is an important factor to be considered in the results of investigations on irrigation methods, and particularly in the duty of water in field practice. The following table gives the total precipitation and monthly distribution for the past four years and for a period of twenty-eight years at the Experiment Station:

MONTHLY PRECIPITATION IN INCHES AT THE NEVADA AGRICULTURAL EXPERIMENT STATION, FOUR-YEAR PERIOD, 1914–1917*

Month	1914	1915	1916	1917	Average	Average from 1889–1916
January	5.46	0.55	6.76	0.05	3.20	2.02
February	0.86	2.59	0.59	2.01	1.51	1.20
March	Trace	0.16	0.33	.74	.31	.83
April	0.70	0.33	0.11	.28	.35	.46
May	0.11	0.52	Trace	1.18	.45	.73
June	0.29	0.00	0.11	.06	.11	.28
July	Trace	0.04	Trace	.04	.02	.36
August	0.38	Trace	0.04	.12	.13	.31
September	0.05	0.06	0.35	Trace	.11	.28
October	0.16	Trace	1.13	Trace	.32	.34
November	Trace	0.28	0.05	.68	.25	.68
December	0.70	1.09	0.97	.27	.76	1.07
Totals	8.71	5.62	10.44	5.43	7.52	8.56

*Information secured from the U. S. Weather Bureau, Reno, Nevada.

It will be seen from the above table that the average annual precipitation for the four-year period of the irrigation investigations amounted to 7.52 inches. In the month of May, 1917, 1.18 inches of rain were

received. With this exception, during no one month of the growing season throughout this period was sufficient rainfall received to affect the moisture content; that is, the small amount of precipitation at any one time was subject to evaporation within a few hours which followed. The results of these experiments are therefore based almost entirely on the water applied by irrigation.

PROJECT 2—VARIETY TESTING AND CROP IMPROVEMENT

These experiments included row tests and also plat tests of several important varieties of wheat, oats, barley, forage and root crops, the object being to determine the varieties of these crops which show special adaptation to the local conditions by their hardiness and yielding capacity, and to improve these varieties by selection. By testing out these varieties in various parts of the State where the altitude and climatic conditions are difficult, it will be possible to determine the highest producing varieties of cereals and forage crops for all agricultural districts of the State.

Cereals

The experiment with varieties of wheat, oats, and barley, included 17 varieties of wheat, 18 of oats, and 17 of barley. Each variety was represented by one row 100 feet long. The seed was planted about one and one-half inches deep in rows one foot apart. The results of the fifteen highest producing varieties were as follows:

RESULTS WITH WHEAT

Variety	Yield per acre of grain—Pounds				
	1914	1915	1916	1917	Average
1. Galgalos Fife C.I. 2398	----------	4,492	3,471	2,821	3,592
2. New Zealand	----------	2,996	4,097	3,040	3,378
3. Colorado No. 50	2,730	3,625	3,452	2,821	3,157
4. Defiance	----------	3,023	3,857	2,580	3,153
5. Rieti	----------	----------	----------	3,100	3,100
6. White Club	3,294	3,096	3,856	1,912	3,039
7. Festes C.I. 1596	----------	2,534	3,304	3,262	3,033
8. Chul	3,222	3,145	2,879	2,858	3,025
9. Blue Stem	3,318	2,855	3,856	1,888	2,979
10. Marquis	2,806	3,505	2,979	2,603	2,970
11. Stanley White	2,724	2,667	2,554	3,185	2,783
12. Minnesota Fife	2,100	3,643	2,978	2,212	2,733
13. White Australian	816	3,299	4,052	2,713	2,720
14. Glyndon No. 692	----------	2,274	3,935	1,937	2,715
15. Minnesota No. 163	----------	2,692	3,365	2,071	2,709

Of the varieties used for four years, Colorado No. 50 was the highest producer with 3,157 pounds per acre. The next four highest yielding varieties in the order named were White Club, Chul, Blue Stem, and Marquis, the greatest difference in yield being 69 pounds. Marquis yielded 187 pounds per acre less than the highest producing variety. Likewise with the next three varieties, including Stanley White, Minnesota Fife and White Australian, 63 pounds is the largest variation in yield.

Marquis and Blue Stem varieties produced a high quality of wheat for milling purposes, and command an excellent market at the local mills. This superiority in quality of grain more than offsets the difference in yield between them and the three highest producers. Of the

varieties tested during the last three years, Galgalos Fife was the highest producer, yielding 3,592 pounds per acre.

Figure 3. High-Producing Wheat Varieties at the Nevada Station.
From left to right:

1. Colorado No. 50 (Wyo.) 3. Blue Stem (Wash.) 5. White Club (Utah)
2. Defiance (Colo.) 4. New Zealand (Colo.) 6. Marquis (Nevada)

RESULTS WITH OATS

Variety	Yield per acre of grain—Pounds				
	1914	1915	1916	1917	Average
1. Early Mountain No. 2 C.I. 656		2,185	3,042	3,301	2,843
2. Early Mountain No. 754		2,041	2,187	2,380	2,203
3. Black American C.I. 549		1,844	1,937	2,694	2,158
4. Siberian C.I. 741		2,054	1,222	3,018	2,098
5. Banner C.I. 751		1,922	1,853	1,965	1,913
6. White Danish		2,011	1,308	2,135	1,818
7. Danish	1,124	1,678	1,494	2,190	1,722
8. Big Four	818	1,895	1,614	2,524	1,212
9. Garton No. 572	663	2,223	1,340	2,492	1,679
10. Ontario Ag. Col. No. 72		1,847	1,035	1,893	1,598
11. Colorado Black	640	1,975	1,412	2,338	1,591
12. Siberian	788	2,064	1,441	1,578	1,468
13. Wisconsin Ped. No. 1	1,060	1,950	1,161	1,635	1,452
14. Kherson	1,425	1,658	994	1,523	1,400
15. Abundance*	692	1,656	982	1,869	1,300

*Average of checks.

Of the varieties tested for three years, Early Mountain was the highest producer with 2,843 pounds or 88.8 bushels per acre, which is 9 bushels greater than any other variety. This variety was affected less than any other by shattering of the seed due to blasting of the panicles before the grain had ripened. With many of these varieties considerable grain had shattered before the plants were ready for harvest.

RESULTS WITH BARLEY

Variety	Yield per acre of grain—Pounds				
	1914	1915	1916	1917	Average
1. Swedish Gold			4,763	4,879	4,821
2. Washington Brewing		3,125	3,823	1,846	3,965
3. Trebi C.I. 936		2,197	3,886	2,813	2,965
4. California Feed	2,367	2,814	3,975	2,547	2,926
5. White Smyrna	2,395	2,522	4,667	2,040	2,908
6. Chevalier	2,720	2,660	3,625	2,595	2,900
7. Heils Hanna No. 682	3,023	1,550	4,166	2,791	2,883
8. C.I. No. 679, France	1,469	3,260	4,924	1,773	2,857
9. Oregon No. 19785	1,465	2,734	4,314	2,766	2,820
10. Moravian 2-rowed	3,086	2,502	3,294	2,376	2,815
11. Princess		2,012	4,352	2,039	2,801
12. Poda C.I. No. 652	1,123	3,141	4,063	2,839	2,792
13. Blue Ribbon 2-rowed	3,040	3,443	4,025	657	2,791
14. Hanna 2-rowed	1,618	3,340	3,991	2,134	2,771
15. White Moravian	3,315	1,561	3,432	2,522	2,708

Of the varieties tested for four years, California Feed barley was the highest producer with 2,926 pounds per acre. In 1916 a new variety of two-rowed barley called Swedish Gold, obtained from Sweden, was included in this test and the average yield for the past two years was 4,821 pounds per acre. This variety is a rank grower, producing an exceptionally heavy yield of straw. If the high yielding power is maintained in the field tests, this will be a very valuable variety of barley for Nevada.

Forage Crops—Including Root Crops

RESULTS WITH ALFALFA

Variety	Leaves—Per cent of plant		Yield per acre—Tons		
	First crop	Second crop	First crop	Second crop	Total
1. Australia 23753	34.6	33.3	3.26	2.68	6.04
2. France 24928	42.1	39.1	3.15	2.61	5.76
3. North Dakota 27247	33.3	38.7	2.72	2.68	5.40
4. Baltic	38.0	38.0	2.75	2.34	5.09
5. Nevada 38	37.1	39.0	2.53	2.51	5.04
6. Grimm	41.4	38.8	2.38	2.19	4.57

First crop harvested July 2, 1917. Second crop harvested August 21, 1917.

The alfalfa varieties were planted with a nurse crop of Chevalier barley in April, 1916, in plats of about one-tenth acre. The first hay crop was produced in 1917 as recorded above. In this test Australia No. 23,753 was the highest producer with 6.04 tons per acre. Grimm made the lowest yield of 4.57 tons per acre. With the highest producer, the crop contained an average of 34 per cent of leaves to stems, North Dakota No. 27,247 contained 36 per cent, while the other varieties averaged 39 per cent of leaves to stems. With the first crop, the variation in proportion of leaves to stems was greater than with the second crop. The third crop did not make sufficient growth to be cut for hay and was used for pasture.

CORN AND SUNFLOWER FOR ENSILAGE, 1917

Variety	Date of planting	Height at harvest	Yield per acre of forage
Improved Leaming corn	May 21	84 inches	28,422 pounds
Russian sunflower	May 21	96 inches	46,240 pounds

In this test a comparison was made of the yielding power and value of corn and Russian sunflower for silage puposes. The Russian sunflower produced by far the greatest yield of 46,240 pounds or 23.1 tons per acre. This crop also reached the proper stage of maturity to make the best quality of silage, a condition which was not true with corn in the experiment. Two small silos were installed to test the feeding value of the sunflower ensilage. No feeding experiment is being conducted with any of these silage crops.

The Russian sunflower is especially well adapted to Nevada conditions and produces a very heavy yield of silage. This is a single-stalk variety which develops a large head about seven inches in diameter.

Figure 4. A 23-ton crop of Russian sunflower grown for silage on the Station Farm.

The seed is planted about two inches deep in a similar manner to corn between the middle of May and the first of June in rows about three feet apart and from four to eight inches apart in the row. When grown for seed about 12 inches should be left between plants in the row. The crop is irrigated and cultivated like corn, and is harvested for ensilage when the seeds have developed to the late milk stage, but before they have been taken by the birds. Where birds are troublesome, the crop should be cut when in the early milk stage and placed in the silo. A

small area of this crop may be cut successfully in a comparatively short time with the ordinary corn knife or sharp hoe with a short handle. In harvesting large areas the corn harvester will be found effective.

The sunflower is ready for harvest by the first of September and thus can be cut green and placed in the silo before any injury is caused by a killing frost. In this respect it excels corn for ensilage, as corn is sometimes seriously injured by a killing frost before it has reached the proper stage of development for silage. The corn grown at the Experiment Station reaches the proper stage of maturity about the middle of September.

After harvesting, the sunflower was cut into pieces about three-fourths of an inch long with an ensilage cutter and placed in the silo. Later it was fed in connection with alfalfa hay and rolled barley to the University dairy herd with excellent results. The coarse stems and heads, including the seed, went through the proper stages of fermentation and worked up into a mealy succulent pulp which was very palatable and was entirely consumed by the stock.

Sudan Grass for Forage and Seed

The results of the tests at the Experiment Station show that Sudan grass will produce a greater average yield of forage or seed than the millets or field peas. When planted in rows and given continuous cultivation, the crop withstands considerable drought. The planting must be delayed until the danger of late spring killing frosts has passed. At the Experiment Station the practice has been to sow from the 15th to the 25th of May. If the crop is to be grown for forage, the seed may be broadcasted or sown with a grain drill not over one and one-half inches deep at the rate of about 20 pounds per acre.

Sudan grass produced about 8 tons of silage per acre at the Experiment Station in 1917. When grown for this purpose the crop is best cut when the seeds have reached the milk stage, generally during the latter part of August. The crop is harvested like alfalfa, run through an ensilage cutter and placed in the silo. The silage is highly relished by dairy cattle and makes a very desirable combination with alfalfa hay, as it is relatively low in protein and well supplied with carbohydrates. Sudan grass should be used for pasture with considerable caution on account of the danger of poison to stock from the prussic acid contained in the immature plant.

The average results for the three-year period 1915–1917 show a yield of 1,218 pounds of Sudan grass seed per acre. When grown for seed the crop is planted in rows from 30 to 36 inches apart, cultivated frequently and harvested when the first heads are fully ripe. Further ripening will result in considerable loss of seed from shattering.

RESULTS WITH POTATOES

Variety	Yield per acre—Pounds					
	1913	1914	1915	1916	1917	Average
Great Divide	21,700	13,025	6,169	7,750	19,086	13,546
Burbank	16,520	10,027	8,096	5,931	24,379	12,991
Peerless	18,460	6,152	6,438	6,516	21,344	11,782
Early Russet	19,220	3,562	7,827	4,579	13,387	9,715
Netted Gem	----------	----------	----------	6,440	11,750	9,095
Early Red	12,160	4,222	5,979	3,954	14,232	8,109

Of the varieties that have been included in this test for the last five years Great Divide, Burbank, and Peerless were the heaviest producers in the order named. These three varieties have been grown in Nevada for many years and the results indicate the value of well-selected home-grown seed over that introduced from other States.

A small amount of seed was grown in 1917 of each of nine leading varieties of potatoes which are being tested in different Western States under irrigation, the object being to obtain a sufficient amount of seed for a comparative test of these varieties in 1918 with our present high producers. Included in this list are Producer, White Rose, American Wonder, Pride of Multnomah, Earliest Fall, Snow (California), Early Prize-Taker, Scotch Rose, and Snow (Oregon).

RESULTS WITH BEETS

Variety	Yield per acre—Pounds				
	1914	1915	1916	1917	Average
Our Ideal mangel	16,616	17,669	60,096	27,497	30,469
Sugar-beet (local)	....	12,465	41,770	23,485	25,907
Mammoth Long Red mangel	14,994	13,155	54,856	18,851	25,464
Golden Tankard mangel	17,172	13,886	48,751	15,751	23,881
Giant Feeding mangel	12,929	20,975	43,065	18,384	23,838
Sugar-beet (foreign seed)	16,275	14,606	41,595	21,269	23,661

The average results of this experiment for the past four years show that "Our Ideal" mangel was the greatest producer. However, the feeding value per acre is considerably less than that of the sugar-beet on account of the high sugar content of the latter. The Dairy Department fed the beets from this test to the cows and considered the mangels only half as valuable as the sugar-beets for this purpose. The variety "Our Ideal" mangel shows a considerable increase in yield and sugar content over the "Mammoth Long Red" mangel. The varieties of "Giant Feeding" and "Golden Tankard" mangels which represent the half sugar-beet are of less value per acre than "Our Ideal" mangel or the sugar-beet on account of the low yield as compared with "Our Ideal," and low sugar content as compared with the sugar-beet.

Date of Planting Sugar-Beets

Since the establishment of the sugar-beet factory at Fallon many requests have been received for information on the comparative yield of early- and late-planted sugar-beets. The following table gives the results of tests for two years including 1913 and 1917:

Date of planting	Yield per acre—Pounds		
	1913	1917	Average
April 23	41,580	24,000	32,790
April 30	40,700	24,250	32,475
May 7	34,430	17,029	25,730
May 14	32,340	15,000	23,670
May 21	36,850	15,591	26,221
May 28	29,920	15,250	22,585
June 4	25,080	9,211	17,145
June 11	22,000	10,081	16,041
June 17	19,800	10,810	15,300

In these results it will be noted that the yields for 1917 were considerably lower than those of 1913. The chief reason for this variation was that in 1917 the beets were grown on an inferior soil. This soil, however, was quite uniform in texture and the results are equally important on the basis of comparison. The average results for the two years indicate that the greatest yields are possible when the planting occurs before the first of May. Very little difference is noted in the average results when the planting occurred during the first half and the latter half of the month of May. The greatest average production of 16.4 tons per acre was obtained with the early planting on April 23. These results indicate the importance of having all beets planted before the first of June, since after that date an average decrease in yield from 11.26 tons to 8.60 tons per acre occurred, the latter yield representing beets planted on June 4.

RESULTS OF CEREAL VARIETIES IN PLATS

Variety	Yield per acre—Pounds		
	1916	1917	Average
Wheat—			
White Club	3,331	1,951	2,641
Blue Stem	2,738	2,010	2,374
Minnesota No. 163	2,495	1,932	2,214
Oats—			
Great Dakota	1,125	948	1,037
Wisconsin Ped. No. 1	884	357	621
Kherson	504	171	338
Barley—			
Chevalier	2,858	1,311	2,135
Moravian	2,720	1,289	2,005

It will be noted in these results that the yield of oats in 1917 was especially low. The lack of humidity, together with the intense heat of the sun during the ripening period, caused the oat panicles to blast and turn white before the grain was fully developed and while the culms and leaves were still green. This caused a large portion of the oats to shatter to the ground before and during harvest.

These varieties of cereals were among the highest producers during preceding seasons in the row variety test. The White Club wheat was the highest producer with this cereal, while but little variation in yield occurred with the two varieties of barley in this test.

Cooperative Variety Tests

Variety tests of wheat and barley were conducted for the last three years on the Truckee-Carson Project in cooperation with F. B. Headley, Superintendent of the United States Experiment Farm at Fallon. The following tables give the results of this experiment for 1917:

VARIETY TEST OF WHEAT

Variety	Yield per acre—Pounds	Estimated yield per acre of local variety on same plat—Pounds
Little Club	1,725	1,630
Rieti	1,778	1,809
Blue Stem	2,160	2,120
Defiance	2,240	2,388
Marquis	2,657	2,513
Sonora	3,062	2,980
Dicklow	3,066	3,000
Ghirka	2,552	2,868

In reporting on these results Mr. Headley states: "The variation in soil was so great that an idea of the relative values of the varieties can be obtained only by comparing the yield of the nearest check plat. The mean yield of all the checks is not taken into consideration. These results show that Little Club, Marquis and Sonora are highest yielding varieties, Blue Stem, Dicklow and Rieti about equal to the 'local,' and Defiance and Ghirka are the poorest."

VARIETY TEST OF BARLEY

Variety	Yield per acre—Pounds	Estimated yield per acre of local variety on same plat—Pounds
Beldi	1,185	952
Hulless	510	1,080
Chevalier	833	1,074
Hannchen	1,040	1,040
Svanhals	842	1,088
Coast	979	1,027

The relative merits of the different varieties of barley were calculated in the same manner as the wheat varieties. Beldi barley outyielded the local variety, while the other varieties were lower in production. Hannchen and Coast were about equal to the local, while Hulless was 50 per cent lower in yield.

Recommendations for Future Projects

The present season will conclude the five-year investigations on the two Agronomy Projects. It is recommended that Project 1 on Irrigation Investigations be continued in a modified form in the Humboldt River Basin in cooperation with Irrigation Investigations, Office of Public Roads, United States Department of Agriculture, through their representative, F. L. Bixby.

Over 50 per cent of the irrigated area in Nevada receives its water from the Humboldt River. Considerable of the irrigated area in the Humboldt River Basin is confined to the production of wild-hay grass. In the irrigation of this grass-hay land excessive amounts of water are used, accompanied by low yields of hay of relatively low feeding value. One of the most important agricultural problems of the State is to increase the production of hay for winter feeding of live stock and to supplement the pasture on the ranges, many of which are at present in a very depleted condition.

In cooperation with F. L. Bixby the following outline of cooperative irrigation investigations in Nevada was prepared and submitted in person at Berkeley, California, by Dean Knight and Mr. Bixby to Dr. Samuel Fortier, Chief of Irrigation Investigations, Office of Public Roads, United States Department of Agriculture:

Subject: **Coperative Irrigation Investigations in Nevada**

This project consists of an economic study of the use of water in connection with the growing of meadow grasses, alfalfa and other forage crops, comparing present wasteful methods of distribution and application of water with more conservative methods and consequent larger crop returns.

Purpose of the investigation:

The purpose of the investigation is to obtain data which will be of value to farmers and stockmen located more particularly in the Humboldt River Basin. In this section of the State there are large areas of land growing native grasses for stock-feeding purposes. Most of this area is irrigated by the wild flooding method with little or no direction or attention. The result has been the production of an inferior crop and a raising of the water table to such an extent as to produce excessive alkali conditions in many places. By the introduction of forage crops of higher feeding values and the cutting down of the wasteful use of water, greater crop returns will be obtained; thus supplementing the depleted ranges, and relieving the water-logged condition of the soil.

Data to be obtained:

1—Area of crop irrigated; 2—Most economic head of water to use; 3—Number of irrigations necessary; 4—Economic depth of each irrigation (inches); 5—Total amount of irrigation water applied (acre-feet); 6—Total amount of waste water (acre-feet); 7—Net duty of water; 8—Evaporation from free water surface; 9—Temperature records; 10—Yield of forage per acre; 11—Yield of forage per acre per acre-foot of water applied; 12—Quality of forage as to its nutrient value; 13—Mechanical soil analyses.

Points to be investigated and results to be obtained:

1. Large heads versus small heads of water for economic application as to cost, including time and labor; and also as to best results in uniform application as shown by soil moisture determinations.
2. Best methods of distribution of irrigation water.
3. Depth to water table at various intervals during the irrigation season and relation of the amounts of water applied to the rise of the ground water.
4. Relation of the height of the ground water table to the soil moisture content.
5. Variation of salt content of soil at different depths throughout the period of the investigation.
6. Importance of the investigation to:
   a. Livestock industry;
   b. Greater production of hay to supplement the already depleted ranges;
   c. Adjudication of water rights;
   d. Hastening of the introduction of more profitable forage crops.

Plan of work:

The plan will be to select typical areas on the Humboldt River, measuring water on present native grasses according to present methods and also according to more approved methods for the purpose of comparison. The introduction of new forage crops including the native grases and clovers, and various annuals; determining the duty of water for each variety.

Rather than have the work scattered over wide distances it is proposed to concentrate the field work in the vicinity of Deeth where water conditions are most favorable. Soil and climatic conditions in this vicinity are representative of the whole Humboldt River Valley and cooperation can be more readily obtained.

At the conference at Berkeley the following memorandum was prepared regarding cooperative irrigation and drainage work in Nevada:

Memorandum Regarding Cooperative Irrigation and Drainage Work in Nevada

It is mutually understood that the Director of the Bureau of Public Roads, United States Department of Agriculture, and the Director of the Nevada Experiment Station will cooperate in irrigation and drainage work in Nevada on the following terms:

1. The period covered by this memorandum shall extend from July 1, 1918, to June 30, 1919.
2. The work to be done under this agreement shall be under the immediate

direction of the chief of the irrigation division of the Bureau of Public Roads, and the Dean of the College of Agriculture of the University of Nevada.

3. The work to be done under this agreement shall cover the following lines:

a. Completion of duty of water experiments in progress at the Nevada Experiment Station during the season of 1918.
b. Completion of duty of water studies in progress in Muddy River Valley during the season of 1918.
c. Improvement in methods of irrigating wild hay meadows in Humboldt River Valley to be begun in the spring of 1919.
d. Drainage of alkalied, irrigated and water-logged lands.
e. Improvement of irrigation and drainage conditions throughout the Humboldt River Valley.
f. Emergency work in irrigation and drainage, including pumping.

4. It is mutually understood that each party to this understanding will contribute to the expense of the work provided for, the sum of $5,000.

5. Complete reports of the work done under this memorandum shall be supplied to both parties to this understanding and either party may publish such results on condition that proper credit is given for the cooperative character of the work.

REPORT OF DEPARTMENT OF VETERINARY SCIENCE

By Edward Records

During the past year four projects have been actively conducted under the Adams Fund:

Project 15—Equine Anemia.
Project 16—A Hemorrhagic Disease Among Cattle.
Project 17—Hog-Cholera Serum Purification.
Project 18—Contagious Epithelioma in Chickens.

Project 21, "Separation of the Active Principles of Anti-Anthrax Serum," was definitely discontinued following the quarterly report rendered under date of December 30, 1917. The basis for this action was the fact that other investigators had quite thoroughly covered the field we had in mind and published their results. It also became apparent on more careful scrutiny of the problem that it was one pertaining more to human medicine and it was thought undesirable to continue it as an Experiment Station project, especially in view of the more urgent work at hand under the projects strictly pertinent to our local problems in animal disease.

PROJECT 15—EQUINE ANEMIA

During the past year work under this project which has been quiescent for several years was resumed and carried on with a fair amount of success. The circumstance which primarily rendered this possible was the discovery of a few cases of the disease of a fairly acute type in the western part of the State where good facilities were available for their study. With the virus obtained from this source the disease was conclusively reproduced under well-controlled conditions, using healthy horses in surroundings where the possibility of natural infection could be excluded. This was something which had not been satisfactorily done in all the previous work under this project. After the second animal passage under these conditions the virus appeared to lose its pathogenicity to a large extent, but in the meantime additional valuable information was obtained by apparently reproducing the disease with serum which had been passed through a Berkefeld filter, thereby demonstrating that the disease we had been working with in Nevada was in this respect analogous to that which has received such extensive investigation in Europe.

It is true the animals referred to above as developing the disease from inoculation with Berkefeld filtrates have not died nor developed a malignant type of the disease, but other horses inoculated with whole blood from the same source at the same time have not done so either, so that the mild type of the disease produced by the filtrates is presumably due to a natural attenuation of the virus strain and not the fact of filtration.

Owing to the fact that the strain of virus referred to above lost its virulence late in 1917 and that there was no qualified man on the staff

who had the time to devote to the work on this project, it again became inactive at that time, the inoculated horses on hand being merely kept under fairly close observation as to general condition and temperature curve up to May 1, 1918, at which time Dr. Wright joined the staff and has since made fairly extensive observations on these animals in the way of blood examinations, etc., with a view of determining their actual condition and forming some opinion as to the prospect of their yielding further information of value. This seems doubtful at the present time, and they will probably be discarded in the near future.

A recent survey of conditions in the eastern part of the State where this disease was so prevalent at one time, but apparently nearly died out during the last few years, seems to show quite conclusively that it has become active there again, causing severe losses in the late summer of 1917. This fact having been determined, we are proceeding on the assumption that a like condition will develop during the ensuing summer and making preparations to actively prosecute work under this project, this being made possible through the addition to the staff of Dr. Lewis H. Wright, who will devote the major portion of his time for at least the next year to work on this disease.

Present plans call for the following major lines of procedure:

1. The treament of naturally occurring cases whenever suitable ones can be found, trying out various procedures along the line of chemotherapy, as this appears to be the only line of treatment offering any prospect of success, the biologic therapeutics of this and analogous diseases having so far failed to yield any promising results.

2. A thorough study of the epizootiology of the disease with special reference to the mode of transmission under natural conditions, laying particular stress on the possibility of its being transmitted by the biting-flies, this being considered well within the bounds of possibility inasmuch as the season of its greatest prevalence coincides fairly well with the season of the year when these insects are most active, namely, late summer and early fall, it seeming possible that the cases occurring later than this may have received their infection during that time and only manifested noticeable symptoms later in the season, being possessed of sufficient natural resistance to maintain apparent good health until that time.

3. In addition to the two main points of attack above, the work on transmission by filtrates will be repeated and fairly extensive experiments carried out to confirm the impossibility of transmitting the disease to other domestic and laboratory animals, a point which does not appear to have been very carefully followed out, at least with reference to the disease as it occurs in the United States. Other points which may arise in connection with natural cases or the studies of the disease under laboratory conditions will receive as much attention as the demands on our time and other resources will permit.

PROJECT 16—A HEMORRHAGIC DISEASE AMONG CATTLE

A great volume of work has been done under this project, the results of which have been in some ways very encouraging, but in others quite disappointing.

Researches into the actual cause of this condition, conducted largely

on the supposition that it was an atypical form of hemorrhagic septicemia due to an infection with the *B. bovisepticum,* have continued to yield nothing which would strengthen this belief. Serological tests upon blood serum drawn from naturally occurring cases, testing same against preparations of *B. bovisepticum,* yielded nothing in the way of definite reactions. Cultural examination of blood samples drawn from the living animal in the same cases proved bacteriologically negative.

In a few selected autopsies where the material was secured in excellent condition a large anaerobic organism was isolated from the liver lesion typical of the disease. So far, inoculation tests by various methods on bovines have failed to indicate that this organism is pathogenic for these animals. In a few instances it proved highly pathogenic for guinea pigs, at other times not, and rabbit inoculations always proved negative.

In spite of the above facts, the extensive vaccination work carried out in cooperation with the State Board of Stock Commissioners, principally in the Carson Valley, using for this purpose vaccines prepared from *B. bovisepticum,* appears to have greatly reduced the number of cases occurring in this district where the disease has always been most prevalent. This reduction in the number of cases has been so apparent as to be self-evident to the stock owners, who are more and more anxious to have this work done.

The treatment of individual cases by the administration of anti-hemorrhagic septicemia serum prepared by us has also yielded wonderfully good results. The percentage of recoveries throughout the whole series of cases treated, taking the cases just as they came without selection, has been about 60 per cent, in marked contrast to the death rate without the use of this serum which was well in excess of 90 per cent. Whether or not this is due to a specific action by this serum, it is too early to say, but there seems some possibility that it is a purely non-specific effect—this opinion being strengthened by the fact that the results obtained from its administration do not vary in proportion to the potency of the serum as determined by laboratory tests on rabbits, a very low potency serum apparently giving as good results in the treatment of naturally occurring cases as one carrying a high antibody content.

During the past year two papers treating of the work under this project have been prepared. The first, "Studies of an Obscure Cattle Disease in Western Nevada," dealt largely with the attempts at the definite diagnosis of this condition and was presented at the fifty-fourth annual meeting of the American Veterinary Medical Association at Kansas City, Missouri, in August, 1917, where it was well received and called forth a large amount of interesting discussion. This paper has since been published in the Journal of the American Veterinary Medical Association, Vol. 5, No. 2, November, 1917. The second, a shorter paper entitled "The Serum Treatment of Hemorrhagic Septicemia," dealing entirely with the results obtained from the administration of the serum referred to above for curative purposes and giving a description of the technique adopted for this purpose, was presented at the Practitioners' Short Course in Veterinary Medicine, University of California, Davis, Calif., in December, 1917. This

also met with a good reception and brought forth a great deal of interesting discussion and relation of experiences by the large number of California veterinarians present, as this disease is also fairly prevalent in parts of that State. This paper has also now appeared in the Journal of the American Veterinary Medical Association, Vol. 5, No. 7, March, 1918.

During the last few months we have succeeded in accumulating a large stock of serum for curative purposes which will enable us to carry on this work extensively when the disease again becomes active this summer, and during the present spring vaccination work has also been pushed successfully in the localities where the most losses from this disease were to be anticipated, the expense of the routine field work in this connection being borne by the State Board of Stock Commissioners, leaving the Experiment Station only to supply the biologicals needed.

From now on the disease may be expected to manifest its usual summer activity, and in addition to its control by serum administration it is planned to renew our efforts looking toward the definite determination of the etiology of this condition. To facilitate this work a supply of young cattle has been procured, so that inoculation experiments can be made immediately when material becomes available, thereby obviating the possibility of same becoming artificially attenuated while subjects are being procured for inoculation purposes. In this work, for the present at least, stress will continue to be laid upon the role played by the anaerobic organisms in the liver lesions, as it is considered these are probably of at least some significance, being the only organisms uniformly present. As this work is carried on, of course other points of attack may present themselves, in which event they will be vigorously prosecuted.

PROJECT 17—HOG-CHOLERA SERUM PURIFICATION

Considerable work has been done under this project, a large amount of raw blood having been processed in separate lots, the technique being varied more or less in each. The results may be summarized as follows:

1. Practically all the antibodies in the Dorset-Niles-McBride hog-cholera serum can be precipitated from the clear plasma by 60 per cent saturation with ammonium sulphate.

2. This wide fraction is necessarily quite bulky, but will dissolve readily in distilled water, the finished solution equaling one-half the volume of original blood.

3. Paper and asbestos filtration of this solution is slow but feasible. Berkefeld filtration has so far proved impossible on a practical scale, but appears unnecessary, as, probably owing to the high ammonium sulphate content, the final solution is self-sterilizing, though no precautions to avoid contamination are taken during processing.

4. The ammonium sulphate used during processing can be removed by dialysis, but such a procedure is not essential, as no noticeable ill effects are observed following the administration of the product undialyzed.

5. The process is scientifically sound, but shows no prospect of com-

ing into practical use, as the expense would be prohibitive except perhaps in the case of concentrating low potency serums instead of discarding the same.

The actual work on this project has been completed except for the potency test on the last lot of globulin solution, which has been delayed owing to difficulties encountered in securing suitable virus for the purpose. As soon as this is accomplished, the work will be written up and the results published in some technical journal, this seeming most desirable, as the subject has no value for a popular bulletin.

PROJECT 18—CONTAGIOUS EPITHELIOMA IN CHICKENS

No spectacular outbreaks of the disease such as prompted the initiation of the project have been brought to our notice during the past year, but considerable interesting material has become available which has been handled to the best advantage possible.

The study of the various affected birds submitted for examination seems to show quite clearly that we encounter, at least in this district, three really distinct conditions as to etiology which present a clinical picture hard to distinguish. These may be summarized as follows:

1. The true contagious epithelioma due to the "scab virus" infection which attacks the skin and all the mucous membranes of the head, the lesions in the latter location being aggravated by secondary infection with many extraneous micro-organisms. This type is highly contagious and will attack vigorous birds in good surroundings. The attempts at controlling this type seem to indicate that the secondary infections referred to above are responsible for the major portion of the loss, rather than the initial infection with the specific virus. This opinion is based on the observation already noted that a "vaccine" prepared from the specific "scab" lesions alone does not give as good results in checking the losses in an actual outbreak as one containing both the specific lesions and the secondary invaders, and that in actual practice the use of a true bacterin made up from the various organisms isolated from the lesions is quite effective in preventing losses, disregarding the initial infective agent entirely.

2. A nonspecific type due to an infection with various micro-organisms. This form does not attack the skin, only the mucous membranes of the head being involved, and all attempts to transmit it artificially to healthy birds have failed. Some little understood condition of reduced vitality of the birds due to improper methods of housing and feeding, or perhaps unusual climatic conditions being essential for its appearance, the occurrence of many cases in a flock appears to be the result of a common cause rather than direct contagion.

Vaccination with the polyvalent bacterin referred to above, even without the aid of improved sanitation, appears quite effectual in controlling this type, even advanced cases recovering under such treatment.

3. A very interesting condition has been encountered in which there are found in the conjunctival sacs and suborbital sinuses, and to some extent the throat, deposits of material distinguished from the pseudo membranes found in types 1 and 2 by a chalk-white color and extremely loose or no attachment. Complete autopsy may disclose the same deposits in the pericardial sac and kidneys. If they have not been

exposed to contamination from outside sources, these lesions are found to be bacteriologically sterile, and the disease cannot be transmitted to other birds by direct inoculation. Chemical tests show this material to be rich in uric acid.

This, taken in connection with the fact that the condition only appears to occur in birds being forced for laying or growth by a highly nitrogenous or "narrow" ration, often with little exercise, seems to show the trouble to be merely a condition analagous to "gout." This is further borne out by the observation that vaccination with the bacterin referred to above has no effect and that the condition yields readily to correction in diet when a broader ration and exercise are provided.

During the year, a large number of birds showing types 1 and 2 of the disease have been vaccinated in cooperation with the State Veterinary Control Service with most gratifying results.

It is planned to continue this as a minor project for at least another year, taking advantage of such materials as come to hand and probably devoting considerable attention to it during the winter months when this group of diseases is most prevalent and work on our other projects not very active. This can be done with very little financial outlay and should yield material for several brief publications of a rather technical nature. The essential points involved in the control of this disease or group of diseases have already been well covered in our bulletins Nos. 82 and 84.

REPORT OF THE DEPARTMENT OF CHEMISTRY

By Dr. C. A. Jacobson

It was decided to limit the work in the Chemistry Department this year to poisonous plants, and more specifically to death camas. In order that the work might be carried on to best advantage, James B. McNair, a graduate of the University of California, was engaged to assist in the chemistry of poisonous plants, beginning the first of August. Mr. McNair had already done some work with plant poisons, especially those of poison oak. He resigned January 1, 1918.

Mr. McNair's time was devoted almost exclusively to the preparation of crude alkaloids from dried poisonous plants. He also worked upon determinations of crude fiber in alfalfa samples from different cuttings. This work was still incomplete at the time of his resignation.

As was explained in last year's report, the summer of 1916 was not favorable to the growth of satisfactory death camas material, and therefore a considerable quantity was harvested last summer to provide sufficient crude alkaloid for this year's work. The material was dried, ground, and extracted, and this work continued throughout most of the year, as the process of extraction was a very slow and tedious operation.

The purpose of these investigations was to isolate and characterize the one or more alkaloids and other poisonous constituents of the plant, in order that they might be identified at any future time. It was also intended to examine these poisons from the toxicological side, in order that authentic data might be placed in the hands of sheepmen to guide them in meeting the menace of sheep poisoning by this plant.

The study of this problem has just been begun and not enough facts obtained to warrant conclusions and publication of the same elsewhere. Considerable data are, however, at hand, and it would seem best to put these in print, for the guidance of any one who decides to undertake chemical work with the plant in the future. For that reason, a short technical discussion of the matter is here presented.

The species of death camas (*Zygadenus*), with which we worked, is most nearly like *paniculatus*. It is quite different from *Zygadenus intermedius* with which Loy, Heyl, and Hepner of the Wyoming Station worked. (Bull. No. 101, Wyoming Station.)

Our species grows at an elevation of from 5,500 to 7,000 feet, and covers a wide area over the Sierra foothills to considerable distances up the mountains. Several hundred pounds of the plant were collected by pulling up the stem, leaving the bulb in the ground. The material was ground through a meat chopper and spread out to dry in the air.

The ground and dried material was extracted with 95 per cent ethyl alcohol three successive times. The alcoholic extract was then removed by pouring off and pressing the residue in the hydraulic press. The extract was then evaporated under diminished pressure till a thick syrup resulted. This syrup was poured with constant stirring into about twenty times its volume of a one-half per cent tartaric acid solu-

tion in water, then warmed gently on the water bath and stirred from time to time, and allowed to stand overnight. In the morning a reddish-brown resin had settled to the bottom of the vessel, which also adhered to the sides, leaving a clear dark-red solution above.

The solution was then evaporated in large evaporating dishes to about one-fourth the original volume. When the concentrated solution was allowed to stand one or two days, more tar or resin separated out, in which well-defined white crystals were found imbedded. At first these appeared to be a tartrate of the poisonous principle, but later were found to be potassium tartrate, and not poisonous.

The concentrated tartaric acid solution was filtered and then

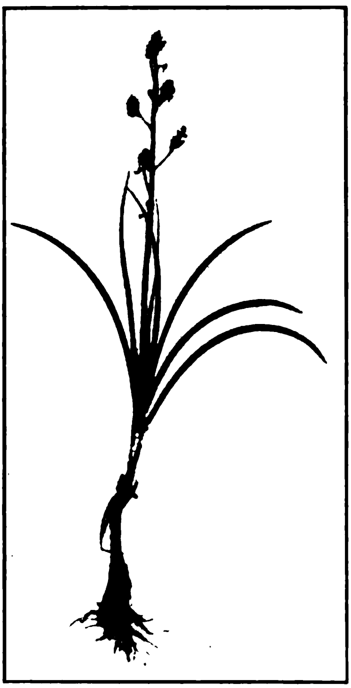

Figure 5. Death Camas Plant, Showing Bulb.

Figure 6. Death Camas Plant Growing in Sagebrush.

extracted repeatedly with ether, to free the alkaloid tartrate from tar and resins. More than a dozen shakings in the separatory funnel were required before the ether remained colorless. The water solution was then treated with a slight excess of sodium carbonate, resulting in a yellowish-brown scum in the solution, as well as an amorphous sticky mass on the bottom and sides of the vessel.

This crude alkaloid was tested and found poisonous to rabbits. The neutralized solution, together with solid, was then shaken in a separatory funnel with ether. The ethereal solution turned yellowish, while the water solution had still a reddish tint. Four or five such extractions

with ether were made and the ethereal solutions combined and part of the ether distilled off on the water bath. If the ether were all distilled off in this way, violent effervescence would take place before all the ether is removed, and the resulting resinous mass would not be poisonous. The destruction of the poisonous principle by heating on the water bath is also true when other solvents are used, such as alcohol, chloroform, acetone, and benzene. This property therefore differs from that of the alkaloid reported by the Wyoming chemists.

When, however, the ethereal solution is removed from the water bath before effervescence begins, and is allowed to evaporate in the air at room temperature, no effervescence takes place, but a reddish sticky mass results which is poisonous to rabbits and guinea pigs.

By rendering the neutralized tartaric acid solution strongly alkaline

Figure 7. Crystallized Alkaloid from Death Camas.

with sodium hydroxide and further shaking with ether, an additional quantity of resinous alkaloid is obtained, which when treated as above, is also found to be poisonous to rabbits. The toxicity of this material is destroyed when heated on the water bath as previously explained. After five or six extractions with ether further extractions with chloroform were made until the chloroform remained colorless. When this solvent was partly removed by distillation, and then by spontaneous evaporation in the air, a resinous and poisonous residue resulted.

The purification of these residues from the two ether extractions and from the chloroform extraction was accomplished by taking them up in 5-per-cent solutions of tartaric acid, again shaking with ether to remove any further tar, neutralizing with sodium carbonate and sodium hydroxide, and again removing the liberated alkaloids with ether

and chloroform. This process of purification was repeated twice for each lot of alkaloid.

The toxicity of the liberated alkaloids was more pronounced after the purifications than before, and when so purified about 0.35 gram was found to be lethal for rabbits when administered per mouth. A great deal of time was consumed in attempting to get the alkaloid or alkaloids into crystalline form. It was decided, for the sake of convenience, to name this poisonous product from *Zygadenus* the Z-alkaloid, and this name is used hereafter.

The Z-alkaloid was found to be soluble in ethyl and methyl alcohol, chloroform, acetone, but much less in benzene and carbon tetrachloride. Attempts to obtain a crystalline product from all these solvents were made by varying the conditions such as time, temperature, and pressure, but all failed except in one case.

When the Z-alkaloid is allowed to stand for two or three months in the air, covered only with a watch-glass to protect from dust, it resinifies into an almost white substance, which can be pulverized well. This resinification does not affect the toxic properties nor its solubility. The material thus resinified has a melting-point between 120 and 134 degrees Centigrade. There is a gradual decomposition at this temperature with only a suggestion of melting, for bubbles of gas form throughout the material.

An apparently different product results when the resinification is allowed to proceed for more than a year under the same conditions; 8.7 grams of the material was extracted with 95 per cent alcohol at room temperature when nearly all went into solution. There remained a crystalline product insoluble in alcohol, which weighed 0.0956 gram or 1.1 per cent of the weight of the original material. This product was in the form of bundles of long needle-like crystals, soluble in water. When crystallized from water the needles arranged themselves in the form of almost perfect fans at the bottom of the vessel. The melting-point of this crystalline product was found to be 245.5°–245.8°C.

Only a very small amount of this material was obtained and therefore only 0.0358 gram could be spared for a toxicological test. This amount was injected into a rabbit intravenously, but it had no effect. The dose was doubtless too small to be effective. The accompanying plate shows the fan-shaped arrangement of the crystals. The magnification in four diameters.

The yield of the purified Z-alkaloid was found to be only about 0.3 per cent of the weight of the dried death camas plant, and therefore the yield of the crystalline product from the plant would be exceedingly small.

Another change in the Z-alkaloid on long standing may be mentioned. When a concentrated alcoholic solution of the original Z-alkaloid was poured into twenty-five times its volume of acetone only a colloidal solution resulted, and finally globules of the substance deposited on the bottom of the beaker as a very viscous liquid, while if the long resinified product is similarly treated, a flocculent amorphous precipitate settles out immediately which can be separated by filtration and washed with acetone. After drying the precipitated Z-alkaloid over concentrated

sulphuric acid, a fine cream-colored powder results, which is stable in the air.

When this precipitated Z-alkaloid was heated in the melting-point tube it began to shrink slightly at 190°C, and showed the first indications of melting at 196°C, while at 198°C melting with decomposition was pronounced.

It was learned that the above-mentioned precipitation was more satisfactory when a mixture of acetone and benzene was used in the proportion of three to one respectively. The filtered and dried Z-alkaloid from this precipitation was tested with several reagents for alkaloids, giving the following results:

Buckingham's reagent	Yellow, Orange, Shade 1
Erdman's reagent	Orange, Shade 2
Frohde's reagent	Yellow orange, Shade 2
Mandelieus's reagent	
Marquis's reagent	Yellow orange, Shade 2
Phosphomolybdic acid	No result
Phosphotungstic acid	White precipitate
Mercuric-potassium iodide	White precipitate
Iodine dissolved in KI	Brown precipitate
Barium potassium iodide	Orange precipitate
Cadmium potassium iodide	White precipitate
Mercuric chloride	No result
Tannic acid	White precipitate
Picric acid	Yellow precipitate
Auric chloride	Yellowish emulsion

Other reagents that will precipitate the alkaloid are lead acetate producing a heavy light-gray precipitate, and barium hydroxide yielding a light-brown precipitate which at first seems gelatinous, but settles out upon standing a day or two.

Other compounds of the Z-alkaloid which are easily made and purified are the picrate and phosphotungstate. The picrate, like nearly all of these compounds, does not have a definite melting-point. It begins to shrink at 165°C, and at 175°C turns to a thin dark-brown core in the tube, while at 182°C this core acquires a glistening surface, which looks as if it had become a viscous liquid. The phosphotungstate does not melt even when the temperature is raised to 300°C. These two salts together with the lead salt and the resinified product furnish the most hopeful means of attack for the elucidation of the structural as well as the empirical composition of the alkaloid. Manifestly, the Z-alkaloid has no similarity to zygadenine, isolated by the Wyoming chemists.

Various other compounds of the Z-alkaloid have been made, such as combinations with cholesterine, iodine, methylate, lithium hydroxide, and bismuth potassium iodide, but none are as well defined and easily handled as the ones already mentioned.

The physiological action of the poison has not been carefully studied. It is safe to say, however, that it produced at first twitchings of the head and limbs, then a comatose condition with rapid and shallow respiration, after which the animal died in a convulsion.

The toxicity of the plant has been determined at different periods of growth and found to be poisonous at all periods except when the plant has dried up in the late summer. The bulbs, stems, leaves, and flowers

have been tried separately, and all these parts of the plant found poisonous.

The toxicological determinations were always made upon the products obtained from alcoholic extractions of the plant, and not by feeding the plant or parts of the plant direct. In keeping track of the poisonous principle in the various chemical transformations of the products from this plant, thirty-seven toxicological experiments were carried out. For this work we are indebted to Dr. Records and Dr. Jakeman of the Veterinary Department of the University.

About 80 grams of the purified Z-alkaloid in liquid form, and 35 grams of the resinified product remained, besides fairly large samples of the salts mentioned, as well as a large sample of the Z-alkaloid precipitated from acetone. The preparation of this material represents a good deal of time and reagents, but it should furnish a good starting-point for the further prosecution of the problem.

The accompanying figures show the entire plant as well as the plant growing in its natural habitat.

Considerable losses to sheepmen, due to the death camas, have been recorded, but nearly always when the pasturage was scanty or following a long and exhausting drive of the herd. Scarcely any danger from this source is felt when the sheep are kept grazing under normal conditions.

REPORT OF DEPARTMENT OF RANGE MANAGEMENT

By C. E. Fleming

Immediately after taking charge of the new Department of Range Management, I made a series of long trips over the State to find out what are the most important grazing problems. In the course of this grazing survey I covered, in a hurried and general way, practically all the livestock ranges within the State. I found that on all the ranges visited, with hardly an exception, the carrying capacity had been materially reduced by overstocking and grazing at the wrong time of the year, due to unregulated use. These trips carried me over the summer ranges and over the desert areas used almost exclusively for winter grazing of sheep; and everywhere I found the effects of a lack of legal control. Because of the absence of any guiding hand and the free help-yourself system, the grazing grounds of Nevada, its most important agricultural resource, are being rapidly depleted.

This unregulated grazing has in many places killed out all the valuable and palatable plants, leaving the range practically denuded of all forage of any economic importance. For the study of these conditions four closely related projects were established, in the Experiment Station: Project 7, Reestablishment of Native Range Forage Plants; Project 8, Relative Importance of Native Range Forage Plants; Project 9, Introduction of Foreign Range Plants, and Project 10, Carrying Capacity of the Range.

With the exception of Project 10 these projects can be studied only on controlled ranges with the assistance of especially trained practical men. At first it seemed desirable to have a large area of depleted range in eastern Nevada set aside for purely experimental purposes, either by Act of Congress or through the Interior Department. Later, conditions in the State made this inadvisable. Until such controlled areas can be secured, however, little progress can be made upon these projects. An area has recently been located, within the holdings of the Utah Construction Company, which has been wholly depleted in the past and which will afford an opportunity for establishing revegetation studies. Due to the pressure of more important projects having an immediate bearing on food production during the war, these projects excepting No. 10 have not been active this year. I recommend that all these projects be consolidated into one Hatch Fund study to be known as Revegetation of Depleted Grazing Grounds.

Project 10 has been studied actively during two seasons, 1915 and 1917. The facts collected include carrying capacity tests of the high summer sheep-grazing ranges under various methods of handling, the effect of trailing to and from an established camp upon the growth of the lamb, the effect of different methods of handling on the carrying capacity of the range, and the influence of different kinds of range on the milk supply of the ewe. These facts, with photographs and drawings, have been prepared for publication.

If time permits, we will make sheep-carrying capacity tests on the low-lying areas supporting mainly sagebrush with a scattering growth of weeds and grasses. However, on account of the war with its demands for increased production, it is very likely that no further work will be done on this project in the immediate future.

The experimental work on Project 6, Poisonous Plants, has been done under actual range conditions during the seasons of 1916 and 1917. We are now planning very active work on this project because of its important relation to the livestock industry. Important facts have been collected, upon the range conditions under which losses from poisonous plants are most likely to occur, together with data as to the best methods of handling animals to reduce such losses. So far, during the season of 1918, the work has been confined largely to feeding the recognized poisonous plants to animals in feed lots under controlled conditions to determine the amount of a plant a sheep must eat in order to be seriously or fatally poisoned.

The facts collected in the field have been put into bulletin form for immediate publication. Because most of the sheepherders in Nevada speak or write Spanish and cannot read English, a part of the bulletin has been translated into Spanish. Seven groups of poisonous plants known to cause losses on the Nevada ranges were discussed under the following headings:

1. Description of the Plant;
2. Plants with which It Is Most Commonly Confused;
3. Distribution and Habitat;
4. Seasonal Growth;
5. Animals Poisoned;
6. Symptoms;
7. Amount Necessary to Cause Death;
8. Treatment;
9. Methods of Handling Sheep to Reduce Losses.

Colored plates were made of the most important plants, with photographs of others. Black-and-white drawings and numerous photographs have been prepared as a means of giving Nevada stockmen practical information on methods of handling sheep and cattle on ranges infested with poisonous plants.

In the feeding experiments the work began with death camas. Tests have shown how much of this plant a sheep must eat in order to be seriously or fatally poisoned. It was found that with different animals the doses vary considerably. The work will have to be carried on for one more season in order to verify the conclusions reached in 1918.

Only one kind of death camas, *Zygadenus paniculatus*, the most important and abundant on the range in this vicinity, has been used. We plan, however, to feed all of the different species of *Zygadenus* that grow on the ranges in Nevada. Autopsies have been made of all animals killed, and notes and photographs were used to record all external symptoms.

Besides the work on the death camas, feeding-tests have been made with rabbit brush, western goldenrod, lupine, prickly peach, milkweed, loco, cow cabbage, and larkspur. Conclusive results have not yet been

obtained from these experiments, but before the summer of 1918 is over we expect to have gained valuable and definite information upon the poisonous properties of these plants.

In order to estimate the degree of danger that exists on the range from any of the known poisonous plants, we have determined how much grass the stomach of a sheep will hold and have made estimates of the amount of any poisonous plant which must grow on a given area of ground in order that a flock of sheep may get a deadly dose. We studied also the palatability of various poisonous plants and the extent to which they are grazed. For death camas the studies indicate at the present time that the probability of sheep becoming poisoned on the range is much less than is popularly supposed.

After an exhaustive search an area has been found for carrying on the white-sage studies under Project 20. The white sage is a typical desert plant, and as such grows where there is no drinking water available for use during the summertime. This bars all field work except when the snow is on the ground. The area selected for study is in the Pyramid Indian Reservation, approximately 60 miles northeast of Reno. A small living stream flows near-by and close to the area, so that the work with the white sage may be continued the year round.

The white sage is probably the most important form of winter grazing for the thousands of sheep which range during the winter on the unwatered desert lands of Nevada.

It grows in the dryest regions, furnishing excellent forage on range that can be used only during the winter and spring because of the lack of water either in the form of living streams or wells. It is now the consensus of opinion of most stockmen who are handling stock on the range yearlong that this valuable form of feed is being exterminated, and that the carrying capacity of the ranges upon which it grows is gradually but certainly being lowered each year.

The primary object of the study of white sage is to work out a system of grazing which will improve and preserve the white-sage ranges and still permit their use. This will require a study of the life-history of the plant, with a detailed study of necessary conditions for its growth, from a grazing standpoint. From all data obtained both practical and scientific it should be possible to devise a system for using these ranges which will not only build up the plant and its associated species, but will also maintain its productivity with a minimum loss of forage through nonuse. This will necessitate (1) the study of the prevailing methods of using white-sage ranges; (2) a study of the life-history of the plant including (a) when growth commences, (b) date when fully matured, (c) manner of its reproduction; (3) date when grazing should begin, based upon the physiological requirements of the plant; (4) date when grazing should cease, and (5) severity of grazing which should be allowed; which will involve (a) the carrying capacity of the plant composition with which it is usually associated, and (b) the number of times the plant may be cropped and still keep up a healthy and vigorous growth.

At the present time there is little definite information about the use of the white-sage winter ranges. During the war it is not advisable to spend much time on this project because it will take several years to

work it out to completion and it can have little immediate bearing upon the increased production of live stock.

The range losses of sheep while down on the desert ranges during the wintertime are oftentimes enormous. These losses are mainly due to deep snows and extremely cold weather. In order to reduce these losses, a study has been made in connection with the white-sage project of supplementing the range forage by concentrates to be used during periods of emergency.

The following are a few of the most important points recorded in the use of cake on the desert:

1. Cottonseed cake should be taken to the range during November, in order to be sure and have it near the feed grounds so it may be transported in case of an emergency.

2. In feeding cake to a flock of 2,500 head of sheep or more, the band should be broken up into smaller units of 500 head so that the poor and weak sheep will have an equal chance with the stronger ones. This is a very important point in feeding sheep on the range; for losses will take place if the poor and weak sheep are not given a chance to get the cake. This they cannot do in competition with the stronger members of the flock.

3. The best times to feed cake are in the morning and at night. During the warmth of the day the sheep should be made to get out and rustle for their feed. When they are cold and the snow is deep they will buck up on the bed-ground and it is almost impossible to move them. However, if they are fed a ration of cake or corn it seems to revive them and they will move when they would not if the cake were withheld.

4. Frequently it is a very difficult thing to get them to eat the cottonseed cake, but this can be readily overcome by soaking it overnight, so that it gets into a mushy mass; they will then eat it readily.

5. When sheep are fed cottonseed cake when the snows are deep and they are forced to graze upon the more or less spiny plants, it prevents them to a large degree from contracting sore mouths. This seems to be due to the fact that it keeps the skin around the mouth from becoming chapped and hard.

6. Sheep from 3 to 6 years of age are able to stand the rigors of the desert to better advantage than either yearlings or sheep over the age of 6 years. Therefore, all gummers and broken-mouths should be kept off the desert in order to avoid losses. All bands having mixed ages should be thoroughly mouthed in the fall of the year.

7. Yearlings ceased to rustle when the snow got nine inches deep. Sheep from 3 to 6 years of age ceased to rustle when the snow had become twelve inches deep.

8. Ewes with a foundation of Merino blood were the hardiest sheep noticed on the desert. Losses from Cotswolds and blackfaces were in excess of those having a foundation of Merino blood. Thus, for successful handling of ewes on the desert ranges a foundation of Merino blood is highly important.

9. Sore mouths on the desert seem to be due to the fact that when the snow becomes deep it covers up all the fine forage such as sand grass, white and bud sage; and the sheep are forced to feed on the

more woody and spiny plants. Their mouths and nostrils are pricked and scratched until they bleed. The blood clots over the sores, the sheep refuse to eat and gradually fall off in flesh, and may die if the deep snows continue.

10. It was figured that at the present prices of wool (40 to 50 cents) per pound, a sheepman can afford to pay as high as $45 a ton for cottonseed cake laid down at the railroad station, plus the haul to the range where his sheep are grazing.

11. When a band of sheep are being grazed on the desert and are not being fed cake, they require approximately one herder to every band of sheep and one camp tender to every two bands of sheep. When they are being fed cake, it requires two men to each band of sheep and a man to haul cake to them, in all two extra men.

12. During the winter of 1916–1917 it cost from $43 to $50 per ton for cake laid down at Elko. The cake was transported to the sheep by wagon. It cost approximately $7 per ton to haul the cake ten miles. The open range with no established road was too rough for motor trucks. A wagon and horses made a more practical outfit.

13. The losses from flocks being fed cake were much lower. On account of the very mild winter last year (1918–1919) there was no opportunity to make further observations on supplementing the desert forage with concentrates. However, at the first opportunity this study will be continued and accurate data secured as to (1) percentage of docked lambs in flocks being fed concentrates and those not receiving any extra feed, (2) effect of concentrates on the growth of the wool, (3) effect of supplementing rough forage on the milk supply of the ewe, (4) difference in losses in flocks fed a concentrate and those not fed, (5) best methods of feeding, (6) proper amounts to feed, (7) advisability of the use of alfalfa on the range with the concentrates, and (8) the desirability of the use of cold-pressed cottonseed cake versus the ordinary cottonseed cake.

A new war-emergency project will soon be submitted, the sole object of which will be to determine from every view-point of the sheep industry the desirability and practicability of (1) feeding sheep during the wintertime, (2) lambing under sheds or in inclosures, (3) producing nutritious succulent feeds conducive to the greatest milk supply during lambing, (4) raising the large number of lambs now annually lost on account of being orphans.

If all of these projects are to be carried on successfully, it will be necessary to employ an additional man having had training in investigative work, more especially that of handling grazing problems.

The services of Mr. N. F. Peterson, botanist, have been obtained; and he will devote a large part of his time to the collection and naming of range plants and to the study of poisonous plants, more especially the study of species which are not considered poisonous, but which may be responsible for a large percentage of our annual losses.

The work for the next fiscal year will be devoted largely to studies tending to reduce annual losses from poisonous plants. We will also study methods of handling sheep on the range which will increase the production of wool and mutton.

REPORT OF THE DEPARTMENT OF METEOROLOGY

By Dr. J. E. Church, Jr.

1. SNOW SURVEYING AND FORECASTING STREAM-FLOW

Whatever extra time could be obtained after teaching and other University duties have been fully met, has been devoted to revising and enlarging the manuscript on Snow Surveying and to obtaining data on some minor problems yet unsolved. Barring unexpected delays, the manuscript should be ready for the printer at or before the close of the present fiscal year (1918–1919).

For purposes of studying the unusual, the present season has been admirable. The snowfall was unusually light during January, but the abnormally heavy precipitation in March increased the mountain snow-cover to 97.4 per cent of the normal.

Since it is believed by some that late-fallen snow melts rapidly and especially since forecasts made this year by ranchers and mountaineers have varied from 50 to 200 per cent of normal, the snow survey the present season has a special significance. The following forecast in tabular form is inserted to show at a glance the general symmetry of snow-cover and stream-flow and the small deviations that are as yet not clearly understood.

General Forecast for Lake Tahoe, April 1

Snow-cover for entire basin	97.4%
Normal rise of lake after April 1	1.67 ft.
Level of lake, April 1	6,227.84 ft.
Maximum level	6,229.47 ft.

Rise of Lake to May 10

	Normal rise	Forecasted rise	Deficiency in rain on the surface	Corrected forecasted rise	Actual rise	Deficiency unaccounted for
During April	+.38 ft.	+.37 ft.	.07 ft.	.30 ft.	.22 ft.	.08 ft.
During May 1-10	+.21 ft.	+.19 ft.	.034 ft.	.156 ft.	.15 ft.	.006 ft.

Total gross deficiency unaccounted for .086 ft.
Total net deficiency; *i. e.*, corrected for daily of 18 C. F. S. .074 ft.
Percentage deficiency to May 10 4.6% of forecast
At 7,000–8,000 feet elevation, approximately 30% of the snow-cover was melted during April.

FURTHER FORECAST

Only .70 in. rain out of normal of 1.78 in. fell in April; and no more fell up to May 16. If, as seems probable, not more than .80 in. of rain falls during the remainder of May and June, the total rainfall for the season of run-off being only 1.50 in. out of normal of 3.94 in., the total correction in the rise of the Lake will be .16 feet or 9.6% of the forecast.

Problems

Three main problems have been considered:

1. To reduce the amount of snow surveying to a minimum and to increase the area served:

2. To detect oscillations in snowfall, especially from west to east over the axis of the Sierra.

3. To determine the causes of certain variations in run-off at present unaccounted for:

(a) Loss in flow due to freezing (?).

(b) Shortage in April, when run-off begins.

The first two problems are being solved by extending the survey area southward to Blue Lakes and westward to Lake Fordyce and Meadow Lake. This was accomplished by the generous cooperation of the Pacific Gas and Power Company. Measurements made at Blue Lakes in 1915–1916 made it possible to obtain comparisons immediately along the axis of the range. The relatively uniformity of the snow-

Figure 8. The Mount Rose Snow-Sampler and Weighing-Gage.

cover for long distances, such as 50 miles, is shown by the following percentages of normal:

Summit Station	83%
Ward Creek	98.8%
Rubicon Peak	93.4%
Mt. Tallac	107%
Lake Lucille	102%
Blue Lakes	96%

This uniformity is probably due to the wide area covered by the "big storms" that furnish the bulk of the winter snow.

The third problem is being attacked by aid of a sand box, through which water is allowed to run under certain controls. A tank above and a catch-basin below complete the outfit. The sand can be pro-

tected against evaporation at will by using a covering of mulch or a canvas.

Experiments with this box have been hindered by the freezing of the contents during the winter. But it is evident that the sand retains some of its acquired moisture long after the run-off has entirely ceased. One wonders, therefore, whether the rains of autumn, if normally copious, are not retained by the particles of sand in sufficient quantity to decrease measurably the amount of additional water required to saturate the soil. Or inversely, whether in 1917 the abnormally dry autumn did not leave the soil so dry that more water from the melting snow than usual was required the present April to prime the soil. At least, the deficiency was .08 ft. despite the fact that the snow cover was late and the temperature for the month .4°F. above normal.

If the effect should be due to lack of autumn rains, the correcting of the original forecast to offset the loss would be simple.

However, a far more vital problem, dependent as much upon a long series of seasonal surveys as upon observation of the flow in the sand box is whether a reduced flow early in the season caused by moderate stoppage of melting is not compensated by an increased flow later in the season. On the solution of this problem depends the accuracy of the revised May forecast. For this purpose a second survey on May 1 is made in one or two typical areas.

PUBLICATIONS

During the year, the paper on Snow Surveying; Its Problems and Their Present Phases with Reference to Mount Rose, read in 1916 before the Second Pan-American Scientific Congress, appeared in the Proceedings of this Congress, vol. II, pp. 496–549.

Reprints of this paper have been widely distributed to serve until the publication of the revised bulletin.

An abstract entitled Snow Surveying has been published in Western Engineering (Feb. 1918), pp. 49–52.

COOPERATION AND EXTENSION

The Department of Engineering of the State of California has informally suggested the extension of the work in the Tahoe Basin to other parts of the Sierra, where they plan to use catchment basins for irrigation as well as for the prevention of floods.

The Pacific Gas and Power Company, with reservoirs on the Mokelumne and the Yuba, have already organized snow parties at Blue Lakes and from Cisco to Lake Fordyce and Meadow Lake.

The supervisors of three National Forests in California are planning to inaugurate snow studies immediately after the war.

Finally, a provisional plan for forecasting the flow of the Humboldt River in Nevada has been requested by the Water Resources Branch of the United States Geological Survey, and furnished. This plan contemplates the use of four courses at the headwaters of the four main tributaries, Lamoille Creek, South Fork, Mary's River, and North Fork.

However, the chief concern at present is to complete the bulletin and to solve the problems already outlined as preliminary to the rapid extension of forecasting stream-flow after the war.

PUBLICATIONS

No. 89, October, 1917—Grain Production in Nevada. By Dean C. S. Knight.

No. 90, February, 1918—Potato Culture in Nevada. By Dean C. S. Knight.

No. 91, February, 1918—Silage Crops for Nevada. By Dean C. S. Knight.

No. 92, February, 1918—Irrigation of Wheat in Nevada. By Dean C. S. Knight.

No. 93, April, 1918—Irrigation of Alfalfa in Nevada. By Dean C. S. Knight.

No. 94, June, 1918—One-Night Camps vs. Established Bed-Grounds on Nevada Sheep Ranges. By C. E. Fleming.

Annual Report for the Fiscal Year ending June 30, 1917.

Technical Papers:

Studies of an Obscure Cattle Disease in Western Nevada; Dr. Edward Records: Journal of American Veterinary Association, Vol. 5, No. 2, November, 1917.

The Serum Treatment of Hemorrhagic Septicemia; Dr. Edward Records: Journal of American Veterinary Medical Association, Vol. 5, No. 7, March, 1918.

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Annual Report of the Board of Control for the Fiscal Year Ending June 30, 1919

PUBLISHED BY THE UNIVERSITY OF NEVADA
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CARSON CITY, NEVADA
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1920

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NEVADA AGRICULTURAL EXPERIMENT STATION

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FINANCIAL STATEMENT

C. H. Gorman

Nevada Agricultural Experiment Station

IN ACCOUNT WITH

The United States Appropriations, 1918–1919

Items		Hatch Fund	Adams Fund
Debit			
To balance from appropriations for 1917–1918		$0.00	$0.00
Receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1919, under Acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund)		15,000.00	15,000.00
Credit	Abstract		
By salaries	1	$9,889.80	$9,483.33
By labor	2	1,969.07	2,485.42
By publications	3	690.71	
By postage and stationery	4	151.58	71.37
By freight and express	5	22.07	120.09
By heat, light, water and power	6	162.52	15.05
By chemical and laboratory supplies	7	93.05	151.41
By seeds, plants and sundry supplies	8	155.63	189.27
By fertilizers	9	0.00	0.00
By feeding stuffs	10	796.00	1,072.41
By library	11	40.45	2.50
By tools, machinery and appliances	12	76.09	33.73
By furniture and fixtures	13	162.05	3.00
By scientific apparatus and specimens	14	0.00	44.67
By live stock	15	280.00	678.00
By traveling expenses	16	395.18	635.20
By contingent expenses	17	0.00	0.00
By buildings and land	18	165.80	14.55
By balance		0.00	0.00
Total		$15,000.00	$15,000.00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Nevada Agricultural Experiment Station for the fiscal year ended June 30, 1919; that we have found the same well kept and classified as above; that the balance brought forward from the preceding year was $0 on the Hatch Fund and $0 on the Adams Fund; that the receipts for the year from the Treasurer of the United States were $15,000 under the Act of Congress of March 2, 1887, and $15,000 under the Act of Congress of March 16, 1906, and the corresponding disbursements $15,000 and $15,000, for all of which proper vouchers are on file and have been by us examined and found correct, leaving balances of $0 and $0.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said Acts, respectively.

(Signed) D. J. SULLIVAN,
State Auditor.

Attest: C. H. Gorman, *Custodian.*

REPORT OF THE DIRECTOR

S. B. Doten

RESOURCES OF THE NEVADA AGRICULTURAL EXPERIMENT STATION

The Nevada Station is supported almost wholly by two federal funds—the Hatch Fund (1887), $15,000, and the Adams Fund (1906), $15,000. In addition the Station has been greatly assisted by a small state fund amounting to $1,000 per annum which made it possible to meet many needs not contemplated in the provisions of the two federal funds.

In the course of the last four years the purchasing power of the Station funds has greatly decreased. Meanwhile it has become necessary to pay higher salaries in order to retain valuable men; and it has been necessary to provide increased facilities for work and better quarters in which to conduct experimental studies. Both needs have been met. The methods by which this was made possible will be given in some detail.

In the first place, it has evidently become necessary to use the available funds only in direct connection with the actual needs of the projects. This has made it necessary to lay down clean-cut and definite plans for project work; to buy more carefully; to decrease expenditures for travel and for apparatus and equipment.

Sale of Apparatus and Equipment.

Meanwhile, in order to provide adequate laboratory facilities it seemed best to sell at war-time prices all superfluous apparatus and equipment, particularly that originally purchased for projects which have been finished. The Department of Meteorology had brought its studies of snow conservation and snow surveying to most important and successful conclusions. There appeared to be no other lines of project work in the Station for which the apparatus and other equipment of the Department of Meteorology could well be used. Nor did there appear to be a good prospect that this apparatus would prove useful in the immediate future. Meanwhile, the U. S. Reclamation Service had need of a strong sea-going launch for use in water measurements in the Lake Tahoe basin; and the Department of Engineering of the State of California needed instrumental equipment for the installation of snow surveys throughout the Sierra.

The Station therefore sold to the U. S. Reclamation Service the launch, Mount Rose, which had been employed in connection with earlier snow studies, obtaining $500 from the sale. A nominal price of $500 was also placed on the meteorological equipment for snow studies and snow surveying; and a sale to the Department of Engineering of the State of California was consummated. Dr. J. E. Church of the University of Nevada was made consulting engineer of the Department of Engineering in California and was given custody of the property sold by the Station. The U. S. War Department found difficulty in obtaining on short notice sufficient platinum to meet the

needs of the war. The Station had on hand a considerable quantity of platinum ware, for much of which substitutes could be readily found. Therefore 10.37 ounces of platinum were sold to the Federal Government at current market rates, netting a total of $1,075.14. Another important sale was consummated in the disposal of the Hilger quartz spectograph, purchased earlier for the Department of Chemistry in the Station, to Cornell University for $500. This instrument had been originally purchased for research work conducted by Dr. C. A. Jacobson, then head of the Department of Chemistry. The purchase proved to be scarcely wise, since very little use was ever made of the instrument. War-time conditions, however, made it possible to dispose of this piece of equipment at a price not far below the purchase cost.

Thus a total sum of $2,575.14 was realized from the sale of superfluous apparatus and equipment, the larger part of which had been of great service to the Station. Throughout the year, moreover, the hide of every animal killed in experimental work was salvaged and sold. All superfluous animals were sold from the Station Farm and every possible measure of economy was used to increase the sales fund.

Meeting the Increasing Cost of Agricultural Research.

Another measure used in recent years to meet the increased cost of scientific work has been a reduction in the number of projects and lines of work to things plainly needed. That is, from the agriculture of the State, at the request of farmers and stockmen, we have picked out a number of problems of vital importance. These problems have been outlined as projects in the Station. The outline was made definite and simple and the work done has been carried on solely for the purpose of solving the problem. The change in policy made it necessary to eliminate certain projects of the highest scientific character whose agricultural connection was less evident. For example, the Station had maintained, from 1906 to 1916, a Department of Meteorology whose chosen field of work was the study of snowfall in the high Sierra. Snowfall is evidently the very life-blood of Nevada agriculture; but engineering methods must be used for the control of water running off from the great reservoirs of snow in the high mountains. As the Station's snow studies progressed it became more and more evident that they would contribute to engineering practice rather more definitely than to farm practice.

This statement cannot be construed as in any sense a criticism of the work itself, which was of the very highest character. But the evident tendency of the projects to give results which could be used only by foresters and engineers instead of by farmers made it clear that as soon as the work could be pushed to reasonable completion it must be replaced on the Station program by the study of problems more genuinely agricultural. Throughout the ten-year period mentioned, the snow studies were very generously financed; the fact that they were so supported gives evidence of a broad and generous attitude of the Office of Experiment Stations toward scientific work even when a little outside the scope of the funds. Evidently, however, with the reduced purchasing power of fixed funds, projects not founded upon actual agricultural problems must be eliminated.

Station projects which are working steadily toward useful results must be adequately financed, otherwise the progress of useful and

necessary projects and lines of work will be greatly hampered by unwise expenditures for things not so important or things not greatly needed. There is, of course, great need of close study in this matter, especially in the case of project work which has been long in progress.

Accounting in the Station.

Closely related to the problem of economy outlined above is the matter of accounting. Under present conditions it is absolutely necessary that the Station Director shall have constantly at hand a set of current accounts covering allotments to departments and projects and showing the daily progress of expenditure. In the absence of such a set of accounts with the departments of the Station, the annual budget of allotments becomes almost meaningless, since there is evidently no way of telling whether the expenditures bear any resemblance to the carefully made plan for expenditure, except in the matter of salaries.

There is kept in the Comptroller's office at the University an admirable set of current accounts under such prescribed headings as Salaries and Labor; Seeds, Plants and Sundry Supplies; Furniture and Fixtures, etc. Naturally, these ledger headings do not correspond to the allotments made to the departments of the Station in the annual budget where certain sums have been set aside for the Department of Range Management, others for Veterinary Science, Chemistry, Agronomy, and Entomology. Mr. C. H. Gorman, the University Comptroller, is an officer of the Station, receiving part salary from the Hatch Fund. The ledger headings for his accounts are schedules required by the U. S. Department of Agriculture, and as such are conscientiously observed. The prescribed system of accounting for the Hatch and Adams Funds used in the Comptroller's office is clearly of the utmost value in classifying the whole set of expenditures made each year by all the Stations.

For local administrative purposes, however, it is insufficient, because the administration of each station fund must be based directly upon expenditures classified according to departments and projects. In order, therefore, to administer the funds carefully, according to the annual budget and in a way to make every dollar go as far as possible, an additional set of books was opened at the close of the fiscal year in connection with the budget for the fiscal year 1919–1920. These accounts will be kept by Miss Hester Mayotte, Librarian and Station Secretary, and will be of great assistance in securing judicious and economical expenditure.

Some Beneficial Effects of Economy in the Use of Station Funds.

The economies resulting from the reduced purchasing power of the funds have not been without good effects upon the Nevada Station. We have found that if the work is to be done effectively with the expenditure of what is in effect far less money, then the following necessary conditions must be wisely conformed to:

In the first place, we have been obliged to base the work of the Station directly upon genuine problems in the agriculture of the State. Every project in the Experiment Station now represents a carefully planned attempt to solve by scientific means an important problem in Nevada agriculture. Every project has been taken up at the request of farmers and stockmen.

The project work is done according to plan. In the first place the scope of the work to be done is carefully thought out and limited.

We are now laying down for each year a working plan subject to constant revision as the experimental work develops. Plainly if the work is not proceeding according to a definite plan, then it is apt to wander aimlessly from point to point without being complete in any aspect; thus it may go on indefinitely for many years and finally be crowded out by the pressure of other needs, with little or nothing to show for the expenditure of many thousands of dollars. In this matter the direction which the work takes month by month is primarily important.

After the plans for project work for a given year have been carefully matured, then a financial budget is made, to provide for the carrying out of the plans. Quarterly reports upon the projects show the progress which has been made and the direction which the work should take for the following quarter. Both project plans and budget are kept flexible enough to provide for unforeseen needs and unexpected results from experimental work.

A current history of each project is kept in the Director's office, showing the origin of the project, the reasons for its study, its local importance, the relation of the work to that of other stations, and the like. The project history is based upon the quarterly and the annual reports of the Station departments. This gives a check upon the relation of work done to work planned and upon the progress of the project toward completion.

Clearly, since many projects are based upon problems touching various departments of the Station, few projects can be regarded as belonging exclusively to any given department. The problems are problems of the State's agriculture, the projects are projects of the whole Station, not of any single department. Since, however, a project may well originate in one single department and yet may need for its solution the work of several sciences, it is evident that it will be best to hold the head of one department responsible for leadership in the work. For example, in Project 22, Poisonous Range Plants, Adams Fund, Nevada Station, the head of the Department of Range Management, C. E. Fleming, is the project leader; but studies of the effects of poisonous plants upon animals naturally concern the Department of Veterinary Science almost as much as that of Range Management. Leadership in the experimental work is therefore vested in Mr. Fleming; the feeding experiments are largely planned by him; but in the observation of symptoms and post-mortem effects he is constantly assisted by Dr. Lewis H. Wright and by assistant veterinarians. Still, the chemistry of poisonous plants is of great importance in any complete study of the matter; for which reason the Station Chemist, Mr. M. R. Miller, spends the greater part of his time in separating out the poisonous matter from such plants and determining its chemical character.

On the whole, the financial difficulties into which the Nevada Station has fallen, in common with other stations in recent years, have led directly toward the requirement that the experimental work done shall be vitally needed, that lines of experimental work which do not prove fruitful shall be discontinued within a reasonable time and replaced by things more greatly needed or evidently more possible of accomplishment, that the work shall be planned in advance and done

according to plan, that the budget shall be based directly upon the project plans, and that throughout the year accounts shall be kept in the Director's office which will show the monthly progress of expenditure; and, finally, that the projects must be regarded as the projects of the entire Station in which several or all departments will share.

Beyond all this, there is evidently an opportunity for economy and added effectiveness in cooperative work among the stations. It is often out of the question for a single station to cover the entire ground needed for the solution of a single problem. There are very few problems so wholly local that they are not agricultural problems in several adjoining States or States with similar climatic conditions. This is preeminently true in animal diseases; it is almost equally so in questions of irrigation practice, dry-farming, poisonous plants, variety testing of grains, and a host of other problems.

In the matter of equine anemia, a disease occurring in a number of States and in various countries, it would seem to be very highly desirable for all the stations interested to share in the study of the problem. First of all, it would be necessary to work out improved methods of diagnosis; then, when it was positively established that all the stations cooperating were actually working upon the same disease, it should not be difficult to divide up the problem into component parts. One station might then specialize in the study of the bacteriology of the disease, another could work more largely upon the transmission of the disease by biting-flies, a third station might give special study to transmission by contaminated food and water, a fourth could work upon the use of vaccines and serums or upon refinements in methods of diagnosis.

In precisely the same way several stations could work upon a poisonous plant growing in adjoining States. One station might be better equipped than another for the study of the botanical and ecological relationships of the plant—all could share in the study of its local distribution. A second station might have excellent facilities for the study of the effects of the plant upon experimental animals. A third might be better equipped than the others for the chemical study of the poisonous elements found in such plants.

Such cooperation would necessarily require comprehensive and intelligent joint planning; it would be necessary for the workers to meet at least once a year to report upon progress made, and to plan for further work. In the long run such cooperative work by a number of stations could hardly fail to result in substantial economies and in added progress.

Improvements in the Station Building.

The sale of apparatus and equipment no longer useful to the Station made available a considerable sum of money with which improvements greatly needed have been made. The space actually occupied by the Station in the Hatch Building was also greatly increased. Upon the completion of the new Agricultural Building Dr. Romanzo Adams of the Department of Economics was assigned new offices and classrooms in Stewart Hall. This released a considerable amount of floor space which was refitted as a workroom in Entomology. Through the cooperation of President Clark, room was assigned in Morrill Hall for Dr. Church's meteorological studies; this set free the entire top floor

of the Hatch Building; and the space was immediately used for the equipment of a botanical laboratory for the Department of Range Management.

The excellent herbarium of range plants, collected between 1900 and 1913 by Messrs. Kennedy and Heller of the former Department of Botany, Horticulture and Forestry, was transferred to the new botanical laboratory in Range Management. The herbarium cases were thoroughly repaired, new shelving was fitted to many of them, and the entire herbarium was gone over by Mr. Peterson of the Department of Range Management and put in readiness for daily use. Large tables, a microscope bench, storage lockers, bookcases, and the usual laboratory furniture completed the equipment of this laboratory. The entire building was then rejuvenated. The walls were kalsomined, the plaster repaired, the stairways carefully repaired, hall linoleums laid, a linoleum put down in the entire botanical laboratory, matters of plumbing and wiring taken care of, and the entire building was put into shape for convenient daily use in scientific research.

At the best, however, the Hatch Building is not modern nor well suited for its present purposes; there is an unavoidable fire danger and the limit of expansion has been reached, since every corner of the building is now in use. The Department of Veterinary Science is already crowded for necessary space; the hoped-for growth and progress of the Department of Range Management will call for facilities of a different character. It is to be hoped that before many years the present Station Building will be replaced by a larger structure carefully planned to fit its purposes.

LIST OF ACTIVE PROJECTS, 1918–1919

Project 1. Irrigation Experiments. Hatch Fund, 1914–1919. Project Leader—C. S. Knight.

The extension of agriculture in Nevada depends primarily upon the use which is made of a limited water supply in irrigation. The purpose of this project during its five seasons of existence has been to determine the conservative water requirements of the principal crops grown in Nevada.

In the beginning, in outlining the project Dean Knight assumed that there are certain stages in the growth of each of these crops at which water is far more necessary than at other stages. In the course of five years study it has been shown that there are such critical stages in the growth of the wheat plant and in other grains. It has also become evident that the alfalfa plant and other leading crops show by their general appearance and the color of the foliage when they are in need of water. The tests have shown likewise that the best rule for irrigation is to give sufficient water at a time when the plants themselves show that they need water. As a result of experiments conducted under this project, the Department of Agronomy in the Station has learned in what way wheat, alfalfa, and other crops show the need of water; at what stages of growth water is most needed; how much water should be applied under average conditions to give the most profitable yields; and how to obtain the highest crop yield from a limited water supply.

The results obtained apply best, of course, to those conditions of

soil and climate under which the experiments were conducted, still the results were not in any way confused by rainfall during the summer months; and the soil chosen is a fair representative of the average soil conditions in Nevada.

The crop yield per acre of land in this State is of far less importance than the yield per acre-foot of water; and, as practically all our agriculture is dependent for its existence upon irrigation, it is evident that studies of methods of obtaining the greatest possible yield from the existing limited supply of water are of fundamental importance to the State.

Project 2. Variety Testing and Crop Improvement. Hatch Fund, 1914–Continuous. Project Leader—C. S. Knight.

It is, of course, of great importance to grow the varieties of wheat, alfalfa, potatoes, and other crops which will give best returns for their cost in labor, land, and water. There are very many varieties of every crop and for many years past the Station has had leading varieties under test. In Dean Knight's variety testing he has done away with a great many varieties tested earlier and has confined his efforts to the testing of a few which are essentially promising. This work has thrown a great deal of light on the conditions under which high-gluten wheats may be produced for milling purposes; and it has shown the strains of alfalfa, wheat, barley, corn, corn for ensilage, and potatoes which are best adapted to the climate of western Nevada.

Project 25. Methods of Increasing Hay Production in the Humboldt Valley. Hatch Fund, 1919–1924. Project Leader—C. S. Knight.

This project was outlined prior to the beginning of the fiscal year and the study was planned as a project to be carried on jointly by the Nevada Agricultural Experiment Station and the Bureau of Public Roads and Rural Engineering of the U. S. Department of Agriculture. A suitable location for the studies was found near Battle Mountain, Nevada; and during the summer Mr. George Hardman of the Department of Agronomy of the Nevada Station did active field work upon the problem. The purpose of the project is indicated by the title, and it is hoped that, as an outcome of the work, methods of irrigation and crop production may be found which will result in increasing the yield of hay from the Humboldt meadowlands—probably the most important agricultural region in the entire State.

Project 23. Revegetation of Depleted Ranges. Hatch Fund, 1916–Continuous. (Consolidating Projects 7, 8, 9 and 10, Hatch Fund.) Project Leader—C. E. Fleming.

The purpose of this project is made clear by the title. The acute need of studies of this type becomes evident only when the student travels far over the sheep and cattle ranges in Nevada and observes their present condition. All work which has been done on this project points clearly to the fact that the cause of the present bad condition of Nevada ranges lies in the lack of regulation and control. Where the public range lands lie open and free to all comers it is to each man's interest to secure as much as possible from the range for him-

self without regard to others or to the future. Our revegetation studies have shown that there is practically no hope of doing anything for the sheep and cattle ranges of the State except under official regulation and control. If the open public ranges in Nevada were placed under federal administration, it would be easily possible so to regulate grazing that the supply of palatable forage would steadily increase, the carrying capacity would become much greater, and from Nevada's ranges there would be turned off each year an increasing number of sheep and cattle.

Project 24. Methods of Increasing the Percentage of Lambs in Nevada Flocks. Hatch Fund, 1919–1921. Project Leader—C. E. Fleming.

The title chosen for this project does not indicate its full scope. Mr. Fleming plans in the future to study methods of producing better lambs as well as more lambs. The bad condition of the sheep ranges has made it necessary to feed hay to lambing ewes to an increasing extent. Under this condition lambs do not thrive as well as has been expected, and the question of a suitable ration of the right feed for lambing ewes is intimately connected with this project.

In the coming fiscal year the Station plans to study the effect of various feeds available in Nevada upon the milk supply of lambing ewes.

Project 15. Equine Anemia. Adams Fund, 1908–Continuous. Project Leader—Edward Records.

This project has been active in the Nevada Station for a great many years. In recent years, however, the disease has decreased considerably in local importance, and, since no very definite results have come from the project, there is good reason to believe that it will soon be necessary to discontinue this line of work in favor of other studies of a more profitable character. In the course of the fiscal year, however, Dr. Lewis H. Wright of the Veterinary Department has made progress in the diagnosis of equine anemia and in the study of other diseased conditions in horses which it closely resembles.

Project 16. Hemorrhagic Disease in Cattle. Adams Fund, 1914–Continuous. Project Leader—Edward Records.

This disease has remained almost as mysterious as it was in 1914, when it first came under study. Its cause is still unknown. Dr. Records has made surprising progress in the treatment of the disease in view of the fact that so little has been discovered concerning its origin. It is at present not entirely clear that the disease is actually caused by bacteria or other micro-organisms. This point will be investigated more fully hereafter.

Project 18. Contagious Epithelioma in Fowls. Adams Fund, 1914; Hatch, 1916–Continuous. Project Leader—Edward Records.

In past years one of the serious obstacles to the growth of the poultry industry in western Nevada has been the prevalence of a disease known as "contagious epithelioma."

This disease has been under study in the Nevada Station since 1914, and methods of treatment have been worked out so successfully that they have been widely adopted in other States.

In the current fiscal year, however, very few outbreaks occurred and there was little opportunity for further study.

Project 19. Biting-Flies of Cattle. Adams Fund, 1916–1921. Project Leaders—E. W. Wells, U. S. D. A., and S. B. Doten.

In various parts of Nevada, horse-flies and other biting-flies have proven to be a serious source of annoyance to cattle on high pasture lands.

In 1916 the problem was started as a project to be studied jointly by the Bureau of Entomology of the U. S. Department of Agriculture and the Nevada Station. The habits and breeding places of the flies were very carefully worked out; and in the course of the present year it became evident that the flies do not breed in cultivated ground, but breed only in badly drained and swampy lands. There is every reason to believe that nothing but the reclamation of such lands through drainage and cultivation will put an end to the biting-fly nuisance. This project will probably be terminated in the coming fiscal year, and written up for publication.

Project 20. White-Sage Studies. Adams Fund, 1916–Continuous. Project Leader—C. E. Fleming.

Studies of the habits of the white sage (*Eurotia lanata*) and the conditions under which it grows and reproduces have shown that this valuable plant must be protected and given an opportunity to reproduce and be guarded against overgrazing unless it is to disappear as many another western range plant has practically disappeared.

Nothing short of additional legislation for the control and wise administration of the unprotected public grazing lands of Nevada will prevent the destruction of the white-sage ranges. The study of this plant will be continued until conservative methods of handling white-sage ranges have been worked out.

Project 22. Poisonous Range Plants. Adams Fund, 1916; Hatch, 1918–Continuous. (Consolidating Project 6, Hatch, and Project 14, Adams.) Project Leader—C. E. Fleming.

Throughout the State of Nevada there is a growing demand for information concerning range plants poisonous to sheep and cattle. This is very evidently due to the fact that when the palatable and nutritious grasses and browse have been eaten out and destroyed there is practically nothing left for the cattle and sheep except the unpalatable poisonous plants. Poisoning is very apt to occur and to increase among hungry animals on ranges where there is little grass, although, ordinarily, poisonous plants would go untouched or would be merely nibbled or eaten in quantities too small to produce death. In the work upon this project Mr. C. E. Fleming, assisted by N. F. Peterson, has studied the habits of growth of various poisonous plants, the conditions under which they grow and spread, and the conditions under which poisoning occurs. They have fed suspicious plants to sheep and cattle in order to determine whether or not they are poisonous. Dr. Lewis H. Wright of the Department of Veterinary Science has shared in this work by conducting autopsies on dead experimental animals and by making careful observations of the symptoms shown

by poisoned animals. Meanwhile, Mr. M. R. Miller, head of the Department of Chemistry in the Station, has isolated the active poisonous principles from several of the plants, and his work has been of great assistance toward the success of the project. Work upon this project will probably continue for several years more.

BULLETINS PUBLISHED DURING THE YEAR

Bulletin 95. Range Plants Poisonous to Sheep and Cattle. July, 1918. By C. E. Fleming. Spanish Translation by B. F. Schappelle.

At the time this bulletin was printed there was an increasing demand for information concerning poisonous range plants. The experimental feeding tests which later became so important a feature of this project had scarcely been started. Because of the war-time situation, however, it seemed best to gather together all existing information concerning range plants known to be poisonous in Nevada, and to issue this information in popular form as promptly as possible. An illustrated bulletin of fifty pages was therefore prepared. The work was based upon field observations and laboratory experiments made by Messrs. Fleming and Peterson. Colored illustrations were used to depict six of the most important poisonous plants. In addition twenty-three drawings and photographs were used to show the characteristics of plants known to be poisonous and to illustrate safe and unsafe methods of handling sheep on the range. In order to make the information contained in this bulletin immediately available to sheepherders, the Station issued a clear and simple Spanish translation by Dr. B. F. Schappelle, then Assistant Professor of the Romanic Languages and Literatures in the University.

Bulletin 96. Irrigation of Field Crops in Nevada. By C. S. Knight and George Hardman.

Nothing is more evident in Nevada agriculture than the need of getting the highest possible crop yield from the very limited supply of available water. Every extension of acreage depends strictly upon the ability of Nevada farmers to make water go a little farther in crop production. In many States the yield per acre is the index to successful farming. In Nevada the yield per acre is of less importance than the yield per acre-foot of water. In Bulletin 96, Dean Knight and his assistant, Mr. George Hardman, have brought together the results of five years experimental study in the irrigation of alfalfa, wheat, potatoes, sugar-beets, and other crops.

During the five-year period, 1914–1918, the summer rainfall was too small to affect the moisture in the soil. The variations in crop yields in these experiments were therefore directly due to variations in the amount of water applied. The most economical use of water with alfalfa was brought about by a total irrigation of 3.5 feet of water applied when the plants showed the need of water by the dark-green color of the foliage. With 3.5 feet of water, 5.59 tons of alfalfa were grown per acre. With 6.3 feet of water, 6.18 tons were produced. It is evident that the increased yield cost altogether too much in water applied.

The experiments with wheat showed that the yield fell off worst when irrigations were omitted at the boot and bloom stages. This showed plainly that the period between the boot and milk stages is a

very critical period in the irrigation of wheat. Experiments indicated that clover should not be allowed to wilt before water is applied. With sugar-beets the tests made it evident that the greatest yield for the amount of water applied could be obtained with 18 inches of water applied in three 6-inch applications.

The results of all these experiments, of course, apply most directly to conditions in western Nevada. In order to make them of greatest value it will be necessary to carry them on as demonstrations throughout the State.

Bulletin 97. Don't Feed Fox-Tail Hay to Lambing Ewes. August, 1919. By C. E. Fleming and N. F. Peterson.

In connection with Project 24, Hatch Fund, Methods of Increasing the Percentage of Lambs in Nevada Flocks, Mr. Fleming and Mr. Peterson have begun active studies of available feeds which will produce the most abundant milk-flow in ewes after lambing. An incident, which

Figure 1. Sheep eating hay containing Fox-Tail. When fed such hay in feed-racks the sheep are very apt to be blinded.

occurred at a point in western Nevada in the spring of 1919, showed that certain kinds of hay commonly fed are not only valueless, but are often highly dangerous.

Timothy hay has proven to be of very little value, and in the case in question the feeding of timothy and alfalfa hay contaminated with fox-tail led to the death of several hundred sheep. Ewes were fed a poor quality of mixed timothy and alfalfa hay containing a great deal of fox-tail. In a little while a number of deaths occurred; and soon outside the corral fence there were several hundred skinned carcasses.

The sharp bearded seeds penetrated the soft tissues of the mouth, becoming imbedded in the gums and setting up such soreness that the teeth became loose and the animal ceased to feed. In a great many cases the bearded seeds penetrated the eyes of both ewes and lambs, causing

blindness. The seeds caught in the wool of the face and bored into the skin and caused abscesses. In other instances abscesses in the ear were due to the same cause. This was the most extreme case of fox-tail injury which ever came to the attention of the Nevada Station. Mr. Fleming and Mr. Peterson, assisted by Drs. Records, Wright, and

Figure 2. A lamb blinded by Fox-Tail in hay. Several abscesses on the face are due to the same cause.

Louck, and Dr. Robert Dill, Inspector of the State Board of Sheep Commissioners, examined a large number of cases and obtained the best possible records of the exact character of the injury done.

The observations and notes were so complete and of so much value that they were published as Bulletin 97 and illustrated by a series of twelve original photographs.

DEPARTMENT OF AGRONOMY

C. S. KNIGHT

PROJECT 1—IRRIGATION EXPERIMENTS

Irrigation Experiments with Alfalfa and Wheat.

The object of this investigation was to determine the critical stages in the irrigation of each crop and to show at what stages of growth the plants are best able to be deprived of an application of water without causing serious injury to the crops; also to determine the amount of water required for the greatest production, and the production with small applications at different stages. With alfalfa a comparative study was made of the plants at different stages of growth with different methods of irrigation to determine the proper stages at which to irrigate these crops, and the proper amount of water to use at each application for the best results. With wheat the object was to determine at which stage or stages of growth an application of water may be eliminated without greatly affecting the yield of grain, and to determine whether or not two applications of water prove as effective as three or more applications with the same amount of water used.

This is the fifth and concluding year of the series of irrigation experiments, and the results of this work are discussed in detail in the the recent Bulletin No. 96 on the Irrigation of Field Crops in Nevada.

Irrigation Investigations with Alfalfa, 1915–1918.

During the four-year period, 1915–1918, experiments were conducted on the irrigation of alfalfa to compare the depth of application, water content of plant, proportion of leaves to stems, yield per acre, and yield per acre-foot of water, when irrigated at different stages of wilting.

In these experiments the water was measured into the plats through two-inch galvanized iron pipes and check plats were used to eliminate as far as possible any variation in soil. The alfalfa was irrigated by the border method of flooding, using small furrows about three feet apart to provide a more ready channel for the water to the lower ends of the plats. The head of water was so regulated as to prevent any run-off. The results herein recorded are, therefore, based upon the actual water used by the plats under the varying conditions presented.

Alfalfa that was allowed to reach the wilting point before irrigation produced a relatively low yield per acre, but excellent returns were realized when irrigation was withheld until the plants turned dark-green in color.

The most economical use of water with alfalfa was accomplished with a total irrigation of 3.5 feet applied when plants showed need of water by dark-green color of foliage, producing 5.59 tons per acre, or at the rate of 1.67 tons per acre-foot of water. Soil-moisture determinations showed that 70% of the six-inch applications was retained in the first four feet in depth of soil. The use on this plat was equivalent during the period of irrigation to a delivery of water at the rate of 1 second-foot for 85 acres, or 0.47 miner's inch per acre.

The highest yield of 6.18 tons per acre of alfalfa was obtained with

a total irrigation of 81 inches when the crop was irrigated before plants showed need of water, but this was accompanied by the lowest yield of 1.03 tons per acre-foot. Compared with the yield of 5.59 tons per acre, the increase of 0.6 ton was obtained at the expense of an additional use of 39 inches of water, which was at the rate of 0.18 ton per acre-foot. Soil-moisture determinations showed that only 25% of the 12-inch applications was retained in the first four feet in depth of soil.

In the irrigation of alfalfa the decrease in soil-moisture content at harvest was generally greatest with the 9- and 12-inch applications. The total amounts of water held in the soil were greatest with the last two stages of wilting.

Results of Irrigation Investigations with Wheat.

The irrigation experiment with wheat included sixty plats. The plats were 22 feet wide by 165 feet long and were separated by levees 4 feet wide. Marquis wheat was used. The seed was not treated, but no smut appeared. It was seeded with a drill, April 4, at the rate of 75 pounds of seed per acre. The plats were harvested during the last week in July with a grain binder. The plats first to ripen were those where two irrigations were omitted, one of which was at the bloom or the milk stage. A four-foot cut around the outside portion of each plat was eliminated to prevent as far as possible any variation due to seepage from adjacent plats.

In the irrigation of wheat during the five-year, 1914–1918, 3- and 7-inch applications were given at two or more of the five stages of growth, including five-leaf, boot, bloom, milk, and dough stages.

Comparison was made of plats receiving an irrigation at each of the five stages of growth with plats in which (1) an irrigation was omitted at each of the five stages of growth; (2) with plats in which irrigations were omitted at any two of the five stages; and (3) with plats that received the same amount of water in two applications, one before and one after heading.

The highest yield of wheat was obtained with 28 inches of water in four applications, when an irrigation was omitted at the five-leaf stage.

The highest yield of wheat with three irrigations occurred with 21 inches of water when applications were omitted at the five-leaf and dough stages.

The average yields of wheat were considerably higher with the 7-inch than with the 3-inch applications.

The yields of wheat were relatively low when irrigations were omitted at the boot and bloom stages, thus indicating that a very critical period in the irrigation of wheat was between the boot and milk stages.

The highest yield of wheat with two irrigations was secured with 9-inch applications, one before and one after heading.

In the irrigation of wheat the high yields per acre were generally accompanied by the greatest decrease in soil-moisture content at harvest as compared with the soil-moisture content before the first irrigation.

Weather Conditions.

The precipitation record for the past year shows a total rainfall slightly above the average. Very little of this rainfall was received

during the growing season, the greater part occurring in the months of February, March, September, and October. The precipitation in May of 0.25 inches was not sufficient to influence the results of this experiment. The rainfall in September occurred after the crops were harvested.

PROJECT 2—VARIETY TESTING AND CROP IMPROVEMENT

These experiments included row and plat tests of several important varieties of wheat, oats, barley, potatoes, ensilage crops, and beans, the object being to determine the varieties of these crops which show special adaptation to the local conditions by their hardiness and yielding capacity; and to improve these varieties by selection. By testing out these varieties in various parts of the State where altitude and climatic conditions are different it will be possible to determine the highest-producing varieties of cereals and forage crops for the various agricultural districts of the State.

Cereals, Row Tests.

The experiment with varieties of wheat, oats, and barley included 17 varieties of wheat, 15 of oats, and 17 of barley. Each variety was represented by one row 100 feet long. The seed was planted 1½ inches deep in rows 1 foot apart. The yields of the fifteen highest-producing varieties were as follows:

WHEAT

Variety	Yield per acre of grain, in pounds						Bushels, average
	1914	1915	1916	1917	1918	Average	
1 White Club	3,294	3,096	3,856	1,912	2,588	2,948	49.2
2 Galgalos Fife C.I. No. 2398	....	4,492	3,471	2,812	994	2,942	49.0
3 New Zealand	....	2,996	4,097	3,040	1,349	2,870	47.8
4 Defiance	....	3,023	3,857	2,580	1,949	2,852	47.5
5 Colorado No. 50	2,730	3,625	3,452	2,821	1,494	2,824	47.1
6 Chul	3,222	3,145	2,879	2,858	1,867	2,794	46.6
7 Marquis	2,806	3,505	2,979	2,603	1,899	2,759	46.0
8 Bluestem	3,318	2,855	3,856	1,888	1,835	2,750	45.8
9 White Australian	816	3,299	4,052	2,713	2,587	2,698	44.8
10 Stanley White	2,724	2,667	2,554	3,185	1,918	2,609	43.5
11 Festes C.I. No. 1596	....	2,534	3,304	3,262	1,140	2,558	42.6
12 Minnesota No. 163	....	2,692	3,365	2,071	1,890	2,505	41.7
13 Glyndon	....	2,274	3,935	1,987	1,786	2,483	41.4
14 Minnesota Fife	2,100	3,648	2,978	2,212	1,394	2,465	41.1
15 Rieti	....	....	....	3,100	1,663	2,381	39.7
16 Marquis*	2,190	2,842	2,934	1,281	1,976	2,254	37.4

*Average of checks.

The yields of wheat were low for 1918 owing to the fact that the seed was sown by hand, with a resulting thin stand. A new hand-planter was purchased and used for seeding the oats and the barley, but did not arrive until after the wheat had been seeded.

Of the varieties grown for five years, White Club was the highest producer with 2,949 pounds per acre. The next four highest-yielding varieties in the order named were: Colorado No. 50, Chul, Marquis, and Bluestem; the greatest difference in yield being 74 pounds, Marquis producing 192 pounds less than White Club. Likewise with the next three varieties in order of yield, including White Australian, Stanley White, and Minnesota No. 163, the greatest variation in yield was 228 pounds.

Marquis and Bluestem varieties produce a high quality of wheat for milling and command an excellent market in the local mills, replacing the hard winter wheat previously shipped in from other States. This superiority in quality of grain more than offsets the difference in yield between them and the three highest-yielding varieties. Marquis has maintained its hardness after growing five years under irrigation.

Of the varieties grown for four years, Galgalos Fife is the highest producer, with New Zealand and Defiance following closely in yield. The yield of Galgalos Fife has been decreasing each year, and averages less than that of White Club.

Oats

	Variety	Yield per acre of grain, in pounds						Bushels, average
		1914	1915	1916	1917	1918	Average	
1	Early Mountain No. 2 C.I. 656	....	2,185	3,042	3,301	1,516	2,511	78.5
2	Early Mountain C.I. No. 754	....	2,041	2,187	2,380	1,672	2,070	64.8
3	Black American	....	1,844	1,937	2,694	981	1,864	58.2
4	Siberian C.I. No. 741	....	2,054	1,222	3,018	801	1,774	55.5
5	Banner C.I. No. 751	....	1,922	1,853	1,965	935	1,669	52.1
6	Big Four	813	1,895	1,614	2,524	995	1,568	49.0
7	White Danish	....	2,011	1,308	2,135	799	1,563	48.9
8	Garton C.I. No. 752	663	2,223	1,340	2,492	936	1,531	47.9
9	Colorado Black	640	1,975	1,412	2,338	1,254	1,524	47.6
10	Danish	1,124	1,678	1,494	2,190	985	1,494	46.7
11	O.A.C. No. 72	....	1,847	1,065	1,893	813	1,402	43.8
12	Siberian Nevada	788	2,064	1,441	1,578	1,053	1,385	43.3
13	Wisconsin Ped. No. 1	1,060	1,950	1,161	1,635	655	1,292	40.3
14	Kherson	1,425	1,658	994	1,523	832	1,286	40.2
15	Abundance*	692	1,656	982	1,869	745	1,189	37.2

*Average of checks.

Of the varieties tested for four years, Early Mountain was the highest producer, with 2,511 pounds or 78.5 bushels per acre, which is about 35% greater than that of any other variety. This variety was affected less than any other by shattering of seed due to blasting of the panicles before the grain had ripened. Early Mountain seed is being sent to different parts of the State, to be compared with the varieties commonly grown in these districts.

Barley

	Variety		Yield per acre of barley, in pounds						Bushels, average
			1914	1915	1916	1917	1918	Average	
1	Swedish Gold	2-row	....	....	4,763	4,879	2,594	4,078	84.6
2	Princess	2-row	....	2,012	4,352	2,039	5,154	3,389	70.4
3	Trebi	6-row	....	2,197	3,886	2,813	3,456	3,088	64.3
4	Chevalier	2-row	2,720	2,660	3,625	2,594	3,482	3,016	62.8
5	Blue Ribbon	2-row	3,040	3,443	4,025	657	3,433	2,920	60.8
6	Moravian	2-row	3,086	2,502	3,294	2,376	3,244	2,900	60.4
7	Heils Hamma	2-row	3,023	1,550	4,166	2,791	2,800	2,866	59.7
8	White Smyrna	2-row	2,395	2,522	4,667	2,040	2,544	2,834	59.0
9	California Feed	6-row	2,367	2,814	3,975	2,547	2,483	2,837	59.0
10	C.I. 679 France	2-row	1,469	3,260	4,924	1,773	2,635	2,812	58.6
11	Hamma	2-row	1,618	3,340	3,991	2,134	2,854	2,787	58.5
12	Brewing (Wash.)	6-row	....	3,125	3,823	1,846	2,374	2,792	58.0
13	New Zealand	2-row	....	2,740	4,917	486	2,956	2,775	57.8
14	Oregon 19785	2-row	1,465	2,734	4,314	2,766	2,275	2,711	56.5
15	White Moravian	2-row	3,315	1,561	3,432	2,522	2,397	2,645	55.1
16	Manchuria*	6-row	1,325	1,867	2,804	1,820	2,968	2,177	45.3

*Average of checks.

Of the varieties tested for five years Chevalier was the highest producer, with 3,016 pounds per acre. Closely following, with yields of 2,920 and 2,900 pounds, respectively, were Blue Ribbon and Moravian. Swedish Gold, a 2-rowed variety, introduced in 1916, heads the list of high producers, with an average of 4,078 pounds. This variety has a very short straw, thus making it difficult to save all the grain with the binder, which condition will prevent its introduction on a commercial basis. The tremendous yield of Princess for 1918 of 5,154 pounds brings this variety into second place with an average of 3,389 pounds. It is interesting to note that of the first eight high producers, with the exception of Trebi, all are 2-rowed varieties.

Cereal Plat Tests

A number of the highest yielding grains in the row variety tests were grown in plats to compare their behavior and yielding power under these conditions. The results with wheat, oats, and barley for the past three years are given in the following tables:

WHEAT

Variety	Yield per acre, in pounds				Bushels, average
	1916	1917	1918	Average	
1 White Club	3,331	1,951	1,788	2,356	39.3
2 Rieti		2,195	1,938	2,066	34.5
3 Marquis			1,985	1,985	33.1
4 Minnesota No. 163*	2,495	1,932	1,489	1,972	32.9
5 New Zealand			1,459	1,459	24.3
6 Galgalos Fife		988	1,753	1,340	22.8
7 Defiance†			1,239	1,239	20.7

*Average of checks. †Reseeded May 4, 1918. Plats 11x264.

In this experiment White Club made the highest average yield of 39.3 bushels. Rieti, Marquis, and Minnesota No. 163 followed in order with little variation in yield. Owing to a poor stand of Defiance, this plat was reseeded. This was partly responsible for the low yield.

OATS

Variety	Yield per acre, in pounds				Bushels, average
	1916	1917	1918	Average	
1 Early Mountain No. 2		1,251	1,279	1,265	39.5
2 Abundance		1,420	433	926	28.9
3 Great Dakota	1,125	948	626	899	28.1
4 Siberian C.I. No. 741			718	718	22.4
5 Wisconsin Ped. No. 1	884	357	653	631	19.7
6 Kherson	504	171	304	326	10.2

Seeded April 15, 1918. Plats 11x264.

In this test Early Mountain No. 2 was the only variety not badly affected by shattering of the grain. Little variation is noted in the yields of this variety for the two years.

BARLEY

	Variety	Yield per acre, in pounds				Bushels, average
		1916	1917	1918	Average	
1	Chevalier	2,858	1,811	1,796	1,988	41.4
2	California Feed			1,972	1,972	41.4
3	Moravian	2,720	1,289	1,839	1,949	40.6
4	New Zealand			1,609	1,609	33.5
5	Blue Ribbon			1,544	1,544	32.2
6	Swedish Gold			1,022	1,022	21.3

Seeded April 15, 1918. Plats 11x264.

In this test Chevalier, California Feed, and Moravian were the highest producers, in the order named, with but little variation in yield. The relatively low yield of Swedish Gold was due chiefly to the loss of grain in binding caused by the shortness of the straw.

Forage Crops and Potatoes

ALFALFA

Average Results, 1917–1918

	Variety	Leaves, per cent of plant		Yield per acre, in tons		
		First crop	Second crop	First crop	Second crop	Total
1	North Dakota	37.9	38.1	2.97	3.02	5.99
2	Australian 23753	27.7	36.6	3.33	2.52	5.85
3	Baltic	40.0	39.8	2.72	2.35	5.07
4	Nevada 38	37.3	37.4	2.49	2.50	4.99
5	France 24928	42.9	38.4	2.61	2.27	4.88
6	Grimm	39.4	40.5	2.75	2.12	4.87
7	Nevada*	38.3	39.3	2.42	2.44	4.86

*Average of checks. Plats 22x110.

Of the seven varieties included in this experiment North Dakota 27247 shows the highest yield of 5.99 tons per acre. With the exception of the check plats Grimm has the lowest yield of 4.87 tons per acre. Little variation occurred in percentage of leaves to stems, Australian 23753 was lowest with an average of 37.1%, while France 24928 was the highest with 40.6%.

ENSILAGE CROPS

Variety	Yield per acre, in pounds		
	1917	1918	Average
Russian sunflower	46,240	39,852	43,046
Improved Leaming corn	28,422	26,095	27,258
Sudan grass	4,977	8,630	6,803

This test included Russian sunflower, Improved Leaming corn, and Sudan grass. Three plats of Marquis wheat were grown as checks. Both corn and sunflower reached the proper stage for ensilage early in September. The yields of sunflower for the two years, 1917 and 1918, averaged 43,046 pounds, while the yields of corn averaged

27,258 pounds. Moreover, the sunflower matured to the proper stage for silage before danger of frost, whereas immature corn was harvested each year for silage.

SUDAN GRASS FOR SEED

Variety	Yield per acre, in pounds				
	1915	1916	1917	1918	Average
Sudan grass	1,099	1,912	642	552	1,061

An average of the four years shows a production of 1,051 pounds of Sudan-grass seed. As nearly as could be estimated one-half of the 1918 yield was destroyed by birds while the seed was in the dough stage. The Sudan grass was sown in drill rows about thirty inches apart and cultivated to keep down weeds and conserve moisture. It was harvested when the first heads were fully ripe.

BEANS FOR SEED

Variety	Yield per acre, in pounds					
	1914	1915	1916	1917	1918	Average
California Large Mexican Pinto	540	296	679	....	681	549

The California Large Mexican Pinto is a bush bean that has been grown for five years with an average production of 549 pounds to the acre. It is a good thrifty grower, a heavy producer, and is valuable as a string bean, but only during a short period of growth. As a dry bean it is unexcelled in flavor and food value.

POTATOES

Variety	Yield per acre, in pounds							Bushels, average
	1913	1914	1915	1916	1917	1918	Average	
1 Great Divide	21,700	13,025	6,169	7,750	19,086	19,177	14,484	241.4
2 Burbank*	16,520	10,027	8,096	5,931	24,379	18,221	13,862	231.0
3 Peerless	18,460	6,152	6,438	6,516	21,344	20,985	13,316	221.9
4 Early Russet	19,220	3,562	7,827	4,579	13,387	14,844	10,570	176.1
5 Early Red	12,160	4,222	5,979	3,954	14,232	8,142	8,115	135.2
1 White Rose	....	....	....	....	23,371	28,223	25,797	429.9
2 Producer	....	....	....	....	23,463	26,264	24,863	414.4
3 Pride of Multnomah	....	....	....	....	16,899	26,590	21,744	362.4
4 American Wonder	....	....	....	....	21,634	19,770	20,702	345.0
5 Jones Russet	....	....	....	....	18,699	18,434	18,566	309.4
6 Snow—Oregon	....	....	....	....	9,090	19,653	14,371	239.5
7 Snow—California	....	....	....	....	12,438	14,778	13,608	226.8
8 Early Prizetaker	....	....	....	....	11,737	12,293	12,015	200.2
9 Scotch Rose	....	....	....	....	11,636	9,949	10,792	179.9
10 Burbank—Oregon	....	....	....	....	10,169	10,388	10,278	171.3
11 Netted Gem	....	....	....	644	11,750	12,301	10,164	169.4
12 Melothian	....	....	....	....	5,636	8,320	6,978	116.3

*Average of checks. Two-row plats, 140 feet long.

Of the varieties included in this test for the last six years Great

Divide, Burbank, and Peerless were the heaviest producers in the order named. The yields were 14,484, 13,862, and 13,316 pounds per acre, respectively.

Of the varieties introduced in 1917, White Rose made the highest production of 25,797 pounds for the two years. Following in order of yield were Producer, Pride of Multnomah, American Wonder, and Jones Russet. All of these varieties made better yields than the highest among the old varieties.

With the older varieties the 1917 and 1918 yields were considerably greater than for the three preceding years, and compared favorably with the average yields of the new varieties for the same period.

PERSONNEL OF THE DEPARTMENT OF AGRONOMY DURING THE FIVE YEARS OF THESE INVESTIGATIONS

CHAS. S. KNIGHT, Agronomist, Project Leader.

J. B. MENARDI, JR., Assistant Agronomist, 1914–August, 1917.

GARDNER CHISM, Assistant Agronomist, September–December, 1917.

GEORGE HARDMAN, Assistant Agronomist, 1918–1919.

PLAN OF INVESTIGATIONS FOR 1920

Project No. 2

The plans for the next year's work on this project will include the continuation of row and plat tests of varieties of cereals and forage crops. New varieties of these crops are being obtained each year, and it is very necessary to compare these with our present high producers. The varieties of these crops that have proved to be especially high yielders under field conditions are being tried out in the various agricultural districts with the idea of determining the most suitable varieties of cereal and forage crops for the respective regions. Representatives of the U. S. Department of Agriculture and the Nevada Agricultural Extension Division are cooperating with the Department of Agronomy in this work, so that the most accurate information will be obtained relative to these variety tests.

Project No. 25

DEPARTMENT OF AGRONOMY, AGRICULTURAL EXPERIMENT STATION, IN COOPERATION WITH IRRIGATION DIVISION, BUREAU OF PUBLIC ROADS, U. S. DEPARTMENT OF AGRICULTURE

1. Irrigation of Wild-Grass Hay Meadows.

This involves the measurement of water for irrigation of wild-grass hay meadows (a) on a 5-acre tract where the investigator controls the irrigation; and (b) on a 10-acre tract where the water is applied by the method of irrigation practiced commonly in the district.

Proper levees will be constructed to provide for accurate measurement of water, a study of the flora made, and yield of hay obtained. The equipment will include five measuring devices.

2. Introduction of Grasses and Clovers in Wild-Grass Hay Meadows.

After a careful survey of the wild-grass hay meadows along the Humboldt River it is considered impracticable by the investigators to plow this hay land for the planting of cultivated grasses and clovers.

It has been deemed highly practical, however, to drill into these meadows seeds of cultivated grasses and clovers to increase the yield and quality of hay produced. This experiment involves the planting in the hay meadows approximately one-third of an acre each of alfalfa, sweet clover, and a grass mixture of timothy, redtop, red clover, and alsike clover, under the three following conditions of irrigation:

(a) Where the water can be controlled and applied regularly.
(b) Where the water cannot be controlled on account of floods.
(c) On low areas where irrigation can be controlled, but where the crop on such areas receives an excess of water.

These grasses and clovers are to be planted this fall on the dry meadows with a grain drill which has a grass-seeder attachment, and thus make an early growth in the spring. A study of the flora will be made and yields of hay obtained.

3. Sweet Clover on New Land in Humboldt River Basin.

A large area of land in the Humboldt River Basin that is irrigated for pasture, consisting chiefly of brush and an occasional stool of wild rye-grass, has a water-table too near the surface for the successful growth of alfalfa. Also a great deal of this area contains a small amount of alkali in the surface layer. On most of this area it is believed that sweet clover will produce excellent pasture and require but little water for irrigation. It will also reseed itself if not pastured too heavily. In this experiment two acres will be planted this fall to sweet clover, with Marquis wheat as a nurse crop. The irrigations will be measured and the yield of hay will be obtained if the sweet clover is saved as hay the first year. The equipment will include five measuring devices.

4. Introduction of Sweet Clover in Sloughs.

A considerable area of the wild-hay land in the Humboldt River Basin consists of sloughs which are now producing a very poor yield and quality of pasture. The water-table varies from two to five feet from the surface, but the land does not contain sufficient alkali to injure the growth of sweet clover. This experiment involves the planting of sweet clover in these sloughs, and broadcasting the seed on the snow in the winter. Observations will be made to note the stand and growth of sweet clover.

5. Annual and Biennial Forage Crops.

This involves the planting in rows on plats of approximately one-twentieth acre each, Russian sunflower, corn, Sudan grass, hog millet, and sweet clover, The irrigations will be measured and yields of forage obtained.

6. Irrigation of Alfalfa.

This experiment includes the measurement of water and obtaining yields of hay under the following conditions of irrigation:

(a) On a thirty-acre tract of alfalfa irrigated in checks, one-half to one acre each, by the practice commonly used in this district.

(b) On two plats, one-fourth acre and two-fifths acre, respectively,

and 350 feet long, irrigated by borders, making possible a quicker and more uniform irrigation, but in other respects similar to the tract under (a).

These experiments will be conducted on land of the Land Development Company. Senator A. G. Macallan, manager of the company, has offered every possible cooperation for the success of these investigations, and we have expressed to him our appreciation of his personal interest and support in this work.

DEPARTMENT OF VETERINARY SCIENCE

EDWARD RECORDS

PROJECT 15—EQUINE ANEMIA

The material which has been available for work under this project during the past year has all come from a locality in which, until October, 1918, this disease was not known to be present—namely, around Fallon, Churchill County. Investigational trips to Topaz, Calif., Washoe, Nevada, and North Fork, Elko County, Nevada, where the disease was supposed to be prevalent, produced no material for research work.

The cases at Fallon occurred on three different ranches at approximately the same time. These ranches are located in three different parts of the valley and are from six to ten miles apart. There has been no interchange of horses among them, nearly all of the animals affected not having been off the ranch for a considerable time. It is of particular note that for about the last eighteen months the disease has apparently been quiescent in all of the localities where it had been present in years past.

With the material from Fallon, the disease was reproduced by whole-blood inoculations in several instances. We were also able to reproduce the disease with Berkefeld filtered material from the same source. We have been able to transmit the disease to a second animal with blood inoculations from the animal which received the Berkefeld filtered material. All these animals have been kept under conditions such that the possibility of a natural infection can reasonably well be excluded. With the exception of two cases, we have been unable to keep the virus alive for more than one transmission, and in these two cases it seems to have lost its virulence to a certain extent, and the animals are apparently developing the chronic type of the disease.

A number of animals, which were hangovers from the previous fiscal year and as reported on in the last animal report, either died or were killed in the early fall. One of the animals which received only Berkefeld filtered material developed an acute form of the disease and died.

Satisfactory cases for therapeutic treatment have not been available, and not very much work has been done along this line. A number of individual cases were treated, all of which died.

An investigational trip was made to Yerington to study a disease which was at first thought to be equine anemia; and, as the animals showed all the clinical symptoms, history and blood picture of equine anemia, eight of the animals were brought to the field laboratory at Reno. Continued observations, blood inoculations, and autopsies proved conclusively that this condition was not equine anemia, but sclerostomiasis. As this condition so closely resembles equine anemia and there seems to be no effective means of differential diagnosis, considerable work is being done along the line of positively diagnosing equine anemia. Blood and splenic inoculations

have been made on rabbits, guinea-pigs, and common mice with negative results. In the event that we are able to develop a virulent strain of the virus, it is intended to make inoculations of other domesticated animals, as some investigators are of the opinion that they have been able to reproduce the disease in swine.

Collections of the various forms of internal parasites have been made from the horses autopsied during the past year. At the present time there seems to be no data regarding the internal parasites of the horse from Nevada, and when sufficient material has been collected and identified it is likely that this information may be used for a publication of some form. At the present time some of these parasites are at Washington being identified by the Division of Zoology.

Nearly all of the investigators of equine anemia have noted among the anatomical changes in the disease that the red marrow of the long bones was greatly increased. During the past year, the long bones of the horses with equine anemia, septicemia, sclerostomes, and other conditions as material was available have been studied and reproduced in the natural colors. The collection is fairly representative, and from our observations there seems to be little, if any, correlation between the extent of the red marrow in equine anemia and certain other diseases—at least, there are numerous other conditions in which the red marrow is as extensive as in equine anemia, and there seems to be no particular reason for laying stress on the changes in the bones for positive diagnosis. It is intended to present this material at the next meeting of the American Veterinary Medical Association in New Orleans in the form of a paper illustrated with colored lantern-slides.

General plans for future investigation will be along the lines of:

1. Endeavoring to find some satisfactory means of differential diagnosis. The method of diagnosing this disease by animal inoculation is slow, tedious, and expensive. It seems highly probable that the complement fixation test might be used in this diagnosis. It is expected that considerable work will be done along this line during the coming year.

2. The blood examinations on the animals with equine anemia and with parasites have not been an effectual means of differentiating this disease. Nearly all investigators have laid particular stress on the presence of large numbers of eosinophiles in the blood of animals affected with parasitic diseases. We intend to check up our blood-counts with careful autopsies, with the intention of trying to find out if there is any relation between sclerostomiasis and eosinophilia.

3. The therapeutic treatment of natural and experimental cases will be continued. Some horses which are under treatment at the present time seem to be lingering longer than usual, and it is thought wise to continue this treatment further.

4. A small amount of work has been done during the past year regarding the relationship of parasitic anaphylaxis and equine anemia, and as material is available further work will be done along this line.

5. In cooperation with the Department of Chemistry some chemical analyses are being made of the blood and spleen of equine-anemia

horses with the hope of finding out what becomes of the red blood corpuscles in this disease. It is highly probable that, as this work continues, other points may come up from time to time which will require some study. As time and opportunity present, these additional questions will be studied.

PROJECT 16—A HEMORRHAGIC DISEASE AMONG CATTLE

Much of the work done on this project during the year has been a continuation along lines already started. Vaccination of cattle in districts where the disease is prevalent has been continued after the original method—namely, the administration of a bacterin prepared from several strains of B. bovisepticum in 5-mil. doses followed in 10 to 12 days by a 2-mil. dose of living cultures of a single strain of B. bovisepticum which has lost its virulence for bovines. In all, 8,829 head of cattle have been so vaccinated during the year.

In spite of the fact that the organism used in this vaccination has by no means been definitely incriminated as the cause of the disease, the results of such vaccination appear favorable, the ranchers and veterinarians actually handling the work at least being convinced that the number of cases is materially less in vaccinated than in nonvaccinated herds in the same environment.

The preparation and distribution of antiserum has been continued. Most of this material has been prepared by hyperimmunizing horses with several strains of B. bovisepticum, but more recently some has been produced using the anaerobic organism isolated from the liver lesions as an antigen. In all, 127 animals clinically diagnosed as cases of this disease have been treated with these sera, mostly with the old-type serum, with results approximating those previously reported. Not enough of the new-type serum has been used to allow of any comparison of results between it and the old.

Investigations looking to the establishment of a definite etiology of the disease have been continued, with, however, no definite results.

The possibility that the condition might be analagous to the one described by Schultz in the Northwest as due to coccidiosis was thoroughly investigated with negative results. Thorough examination of feces and tissues from naturally occurring cases failed to reveal anything resembling coccidia. These negative findings were checked by comparison against positive material kindly supplied by Dr. Schultz and further confirmed by an oral communication from Dr. O'Bannion of California, who stated that they had both conditions in his State and that they were readily differentiated upon direct comparison.

Considerable work with the anaerobe found constantly in the liver lesions was carried out, satisfactory means of its routine isolation having been devised. The pathogenicity of this organism, however, for either laboratory animals or bovines has not been demonstrated. In a few instances, small animals have died following its injection, but only in a small per cent of trials. One interesting point in this connection was, however, established—namely, the persistence of the organism in the tissues without apparent effect on the host. The organism was recovered from the kidneys of a rabbit twelve days after the administration of a pure culture intravenously,

the animal having to all appearances remained normal during the interval.

The actual identity of the organism cannot be considered as established. Pure cultures were submitted to Dr. K. F. Meyer of the University of California, who is conducting extensive work on the anaerobes. He at first classed it as B. bifermentans, but later modified this slightly, designating it as "one of the group."

Serological tests upon blood samples from natural cases, using the anaerobic organism as an antigen, have failed to produce any positive results. The difficulties in technique incident to the peculiarities of the organism may have been largely responsible for this failure, however, and further work along this line is contemplated in an attempt to overcome the obstacles encountered.

A large number of attempts to reproduce the disease in bovines by the oral administration of intestinal contents and organ emulsions, injection of various organ emulsions and pure cultures of the anaerobe subcutaneously, intramuscularly and directly into the gall bladder and liver have all uniformly failed.

Under general considerations it may be said that the disease still continues to be of economic interest, for, while its prevalence in the Carson Valley appears to be decreasing, it is appearing in new localities—as Mason and Smith Valleys, the Fallon district, etc.—and becoming more frequent in the Truckee Meadows.

While reluctant to make such a statement, it would seem at this time that there might be at least a possibility that this disease is not an infectious one, this point of view being suggested at least by the uniform failure of attempts at its transmission by methods which by their very crudeness as to materials used should assure their success. It may be that the solution of this problem will be found in an explanation based on some metabolic disturbance due to peculiarity of diet or environment and not an infective agent.

PROJECT 17—HOG-CHOLERA SERUM PURIFICATION

Active work under this project was concluded during July, 1918, and, as opportunity presented, the data obtained were compiled and checked for the final preparation of an article setting forth the results of the work and the conclusions drawn from it. This final article will be finished and published in some technical journal during the fall of 1919.

PROJECT 18—CONTAGIOUS EPITHELIOMA IN CHICKENS

Very little work was done under this project during the year. The pure type of this disease, due to the specific virus causing the wart-like growths on the skin, appears to have practically become extinct in this State, for the time being, at least.

Some work was done in the way of isolating miscellaneous bacteria from outbreaks of the nonspecific or "roup"-like outbreaks and preparing a bacterin from same which gave very satisfactory results in controlling the type of disease encountered.

Nothing was done along the line of purely scientific work with the virus causing the true contagious epithelioma, the suspension of efforts along this line appearing best in accord with the general policy of the

Station to place all available energy upon problems of actual economic importance to the agricultural industry.

Unless it appears desirable to revive this project by the prosecution of purely scientific research, it would appear that it might well be concluded at this time, as the means for controlling the various types of disease in this group have been worked out to such an extent that the problem is purely one of control work, and as such can be adequately handled by the State Veterinary Control Service.

STATION CHEMICAL LABORATORY

M. R. MILLER

The work of the Chemical Laboratory for the fiscal year 1918–1919 has tended toward division into two main groups—contributory and research work.

The contributory work of the laboratory has consisted principally of analytical work for members of other departments. Analyses of silage used in feeding experiments by Professor Wilson were made. Dry-matter determinations were carried out upon young forage grasses grown by the Department of Range Management. For Dr. Wright of the Veterinary Department in his work on equine anemia, samples of blood and spleen were analyzed for their iron content with the view to the possibility of correlating the data so obtained with other variations in the blood of affected horses. Several miscellaneous samples have come to the laboratory for attention, among them being waters, ashes, fertilizers, and squirrel poison.

The research work, being upon the range plants which have been found poisonous to stock in feeding experiments by the Department of Range Management, while differing from analytical work, may also be considered practically as contributory work inasmuch as the results may have a bearing upon the management of the range as promulgated by that department. The chemist, on taking up his duties on September 1, 1918, found the laboratory well equipped for this type of work. The possession of such a laboratory by the Station well justifies the continuation of research work in this direction, because the data obtained will not only add to scientific knowledge, but are related directly to the agricultural pursuits of the States.

The plants investigated have been *Atriplex canescens,* one of the saltbushes, and *Prunus demissa,* or the wild chokecherry.

The work on *Atriplex* has disclosed the presence in the plant of a saponin or a mixture of saponins to which it may be possible to ascribe some of the poisonous properties of the plant. Preliminary tests upon this material, a small amount of which has been isolated, have shown it to have the characteristic properties of saponins—hemolytic action on blood corpuscles, affinity for water, toxicity toward fish, lack of nitrogen and foaming in aqueous solutions. A method of preparation of the material has been clearly indicated, and it now remains to prepare a sufficient quantity to study more closely in order that the work on this plant be sufficiently rounded out.

Prunus demissa, which claimed the writer's attention during the early part of the year, was shown to contain a cyanogenetic compound. The toxicity of this plant is undoubtedly due to the prussic acid generated by enzyme or other action. It is possible that there is a seasonal variation in the available amounts of the poison, and in such a case knowledge of the least harmful period would furnish data applicable to the use of this plant as forage. To such an end an investigation of the seasonal variation seemed advisable, but was not undertaken this

spring as was originally planned. To obtain the desired data it is necessary to conduct analyses of the plant at intervals of several weeks during the growing season. The methods used for such analyses should be as near above reproach as possible, and a further study of methods was deemed advisable. To this end experiments have been carried out which tend to show that the prussic acid may be accurately determined by a method of aeration under reduced pressure at ordinary temperatures in contrast with the distillation method previously used by investigators on similar plants and to the accuracy of which serious questions have been raised.

On account of the shortage of students during the past college year it has been difficult to obtain laboratory help, to say nothing of student assistants for some of the simpler operations in the chemical work. With the return of normal college conditions, it is expected that more assistance will be obtained.

DEPARTMENT OF METEOROLOGY

S. B. DOTEN

From 1906 to 1916 the Nevada Station maintained a Department of Meteorology which was headed by Dr. J. E. Church, assisted by Professor S. P. Fergusson and Arthur Smith. Dr. Church carried on studies of frost and snow which from the beginning attracted much favorable attention in scientific circles. The frost studies were terminated in 1916 and published in Bulletin No. 83, "Value of High-Level Meteorological Data in Forecasting Changes in Temperature." The snow studies were continued until the summer of 1917, when it

Figure 3. Instruments for the study of Climate and Snow, Mount Rose, near Lake Tahoe, at an altitude of 10,800 feet.

became necessary to use the funds of the Station in projects of greater agricultural importance. It had become clear that Dr. Church's studies of snow in the Sierra Nevada would contribute more directly to engineering and forestry than to agriculture. While the necessity of employing the Hatch and Adams Funds for strictly agricultural purposes made the termination of the meteorological projects inevitable, still the outcome of the snow studies has since been watched with keen and cordial interest; and every possible assistance has been given toward their completion.

In 1918 the equipment of the former Department of Meteorology was sold by the Station at a nominal price to the Department of

Engineering of the State of California, by whom, under Dr. Church's direction, the Station's snow studies will be completed and put into practical use.

In this connection the sixth biennial report of the Department of Engineering of the State of California states:

> In previous reports of the Department of Engineering, the desirability of being able to forecast the probable magnitude of floods and the duration of run-off for all streams furnishing water for use, has been discussed. * * *
>
> It is contemplated that ultimately reservoirs will be built in the mountains to retain a portion of the floods, so as to reduce the quantity to be cared for by the flood-control works in the valleys. * * *
>
> But it will be necessary to know beforehand when to begin filling the reservoirs. If they should be filled with early flow of water before it has reached flood stage, and then a flood came, there will be no place to store any of it. On the other hand, if they are held empty until flood danger is past, there may be not enough to supply the needs of irrigators and other users.
>
> * * * The source of all floods and of the major part of the late-season flow is the vast snowfields about the heads of the streams.
>
> The department holds, and has so pointed out in previous reports, that surveys of these great snowfield reservoirs should be made and the water content ascertained. From the information obtained, a forecast can be made of the quantity of water that will come down when the snow melts. Such information will be valuable, not alone in directing the operation of filling artificial reservoirs, but in giving foreknowledge of the summer flow, so that the farmer may conduct his irrigation to meet conditions.

The report goes on to discuss the types of meteorological instruments needed to obtain data on climate and snowfall conditions, and then states that—

> Professor J. E. Church, Jr., of the University of Nevada, has probably given more scientific study to the subject than any other man in the United States, if not in the world. From a pure regard of the scientific aspect, and a love of nature which finds delight in communing with her in all her moods, Professor Church has prosecuted his investigations for some years, mostly alone, but more recently in cooperation with the local representatives of the U. S. Reclamation Service and the U. S. Weather Bureau.
>
> Although convinced that the study of snowfall in its relation to stream-flow is of great importance and that it is one of its proper functions, the Department of Engineering has heretofore had neither apparatus nor funds with which to make the investigations.
>
> The Legislature two years ago authorized the department to engage in this line of research, but the Act did not become effective in time to do anything last winter. Upon taking up

> the subject, it was found that some of the instruments required are not made by any manufacturer and can only be obtained by having them made to order. Under war conditions, it was found impossible to have this done.
>
> Fortunately, however, through the good offices of Professor Church, the department has secured enough apparatus (and practically all there is in the United States) to enable investigations to be made upon the headwaters of about seven of the principal streams of the Sierra, four of which run into the Sacramento and San Joaquin valleys, and three into the irrigated districts of Nevada.
>
> Tentative agreements have been made for the cooperation of the U. S. Forest Service, U. S. Weather Bureau and Reclamation officials, as well as of some large users of water in the territory named.
>
> Professor Church has generously placed his knowledge and experience at the service of the department, and it is felt that it is engaging upon a line of research that will result in very great good.

It is evident that in selling the equipment of the former Department of Meteorology to the California State Department of Engineering, the Station has laid the right foundation for the continuance and the practical application of the results of its former project work in snow studies.

For several years the Nevada Station has planned to issue an elaborate technical bulletin covering in detail the method of snow surveying worked out by Dr. Church, together with tabulations of the results of many years' snow measurements and of various climatic data connected with snow surveying. As the material was gradually put into form for publication it became increasingly evident that the data presented would be of far more use to students of engineering than to students of agriculture. For this reason the Station has cordially agreed to an arrangement brought about by Dr. Church whereby all information on snow surveying will be published by the Department of Engineering of the State of California and will be by them distributed in engineering circles.

The importance of snowfall studies to engineering is further emphasized in a recently published article by Professor Robert DeC. Ward of Harvard University, "The Snowfall of the United States" (Scientific Monthly, November, 1919), in which Professor Ward states:

> In the drier sections of the United States many of the most important problems with which engineers have to deal, whether in connection with railroad construction and operation, or hydraulics, or irrigation, or general water-supply, are connected with the depth and conditions of snowfall, and with the amount of water which its melting will supply. In California the mountain snowfall has well been termed the life-blood of the State, and the same is true of most of the vast territory west of the Rocky Mountains.

Thus, the Station finds that its prolonged and highly expensive study of Sierran snowfall made between the years 1906 and 1917

will have an immediate useful application in an adjoining State which will indirectly be of considerable benefit to western agriculture. The value of Dr. Church's good work in the measurement of snowfall has recently received added recognition in Europe. In Switzerland the study of snowfall is of the highest practical importance, particularly in the matter of the study of run-off from the Alps and of conditions which lead to the formation of avalanches. Recent

Figure 4. Driving the Church Snow Sampler in Deep Snow, Sierra Nevada Mountains.

reports from the Swiss Glacier Commission show that Dr. Church's snow sampler and weighing devices have proven very useful in the study of Alpine snows, and there is a good prospect that the methods of snow measurement worked out by Dr. Church, S. P. Fergusson, and Arthur Smith in the Nevada Station will find world-wide use in the survey of accumulated mountain snows.

DEPARTMENT OF ENTOMOLOGY

S. B. DOTEN

PROJECT 19—BITING-FLIES OF CATTLE

Early in the summer of 1918 active field work was resumed upon the project in the field insectary at Topaz, Calif., by J. L. Webb, of the Bureau of Entomology, U. S. Department of Agriculture, and Mr. Noble Waite, a student assistant assigned from the University of Nevada.

In the course of the summer Mr. Webb made excellent progress toward the completion of life-histories of *T. phænops* and *T. punctifer*. An attempt was made to introduce egg parasites for the control of *Tabanus phænops*. The results of the introduction cannot yet be ascertained.

From the beginning one of the most difficult features of the studies conducted under this project has been the study of the egg-laying habits of *Tabanus phænops*. This fly causes far more annoyance than any of the others in the region under study; and it is therefore of especial importance to find under what conditions the eggs are laid and to find the usual breeding-places of the larvæ. After prolonged and most painstaking observation Mr. Webb found a considerable number of egg-masses on short grass and sedgy growths in typical wet meadows. Larvæ in various stages of growth were also observed and the life-history of this insect was completed.

The most important feature of the project work now remaining for investigation is the study of soil-moisture conditions under which the larvæ thrive. Apparently they require soils sufficiently wet and soft to permit them to range freely in search of food. In the coming fiscal year soil and moisture conditions in alfalfa fields and along the banks of irrigation ditches will be thoroughly studied in order to find out whether the larvæ are found in any location except in the swampy undrained meadow lands.

These studies will probably terminate the project, and it is expected that they will show clearly that the only hope of any great decrease in the number of the flies lies in drainage and the reclamation of the swampy portions of valleys where these flies are now abundant.

The introduction of egg parasites will not, however, be abandoned and it is possible that this measure may in the long run prove effective.

DEPARTMENT OF RANGE MANAGEMENT

C. E. FLEMING

The following is, in a general way, a brief summary of the work which has been accomplished in this department during the past fiscal year. Before dealing separately with each project it may be well to state that the major part of the work has been devoted to the studies of poisonous plants. This project has developed to such an extent during the past two years that it has left little time for the other approved projects; and because of the proportions that it has assumed, it has used most of the funds allotted to this department.

PROJECT 22—POISONOUS RANGE PLANTS

This project was commenced on an active basis during May of the year 1918. While the work has been progressing rapidly and satisfactorily, new plants poisonous to range stock are from time to time being discovered, so that it may not be possible to terminate this work until the fall of 1921. It is hoped that the larger part of the work will be accomplished by this date. However, there is always the possibility that at any time a new plant may be discovered that would have to be actively studied. Further, the cause of the mysterious "swell-head" in sheep has not as yet been discovered; and at the present time there is a strong belief among stockmen that it is due to some plant. Thus no definite date can be set at the present time as to the probable completion of this project. In view of what we know now, it may be quite safely stated that the major part will be concluded by the fall of 1921.

The studies have been confined largely to control-feeding tests with cattle and sheep at the field laboratory, supplemented by field observations. Outside of the Station personnel there have been no cooperators. The leadership of this project has been from the start within this department, although much valuable information has been contributed by Dr. L. H. Wright of the Department of Veterinary Science, who has been performing the autopsies, and to Mr. M. R. Miller of the Station Chemical Laboratory, who has been working on the plant poisons found in the various plants studied.

During late years the losses from poisonous plants have been on the increase. This is probably due to the fact that as the valuable and palatable forage on the range becomes gradually depleted the range animals are forced to eat plants which years ago, when there was an abundance of feed, were seldom, if ever, touched. Most of the poisonous plants contain substances which are not relished by animals, but when under the stress of hunger they will eat them, the result often being large numbers of fatalities.

Many of the deaths which have been taking place in the past could not be ascribed to the recognized poisonous plants, and thus it was necessary to initiate control-feeding tests in order to determine which plants on the ranges were directly responsible for the deaths of animals. These control-feeding tests, supplemented by field observa-

tions and chemical studies, have for their object the finding out of the following information: (1) the plants which are toxic; (2) class of animals affected; (3) approximate amounts necessary to cause sickness or death; (4) conditions under which poisoning takes place; (5) description, habitat, and distribution of the poisonous plants; (6) toxic substances responsible for the poisoning; (7) possible remedies, and (8) methods of handling on the range so as to keep losses down to a minimum.

During the past fiscal year these studies have covered thirty different kinds of plants. There were 211 separate feeding tests made, some of which involved feeding the same plant for several days in succession. The following table gives the plants fed which so far have only given negative results. However, these tests are only preliminary and are in no sense to be taken as conclusive as to the toxicity or nontoxicity of the plant.

PLANTS FED DURING YEAR WHICH, PRACTICALLY SPEAKING, GAVE NEGATIVE RESULTS

Plant fed	No. of trials	Amount fed	Animal fed	Remarks
Astragalus purshii	1	22 lbs.	Ewe and lamb.	Fed to see if it would cause ewe poisoning.
Glyptopleura marginata	1	0.4 lbs.	Yearling lamb.	
Ranunculus macounii	1	5¼ lbs.	Sheep	
Senecio nelsonii	1	1¾ lbs.	Calf	Collected in pasture where animals were suspected of being poisoned.
Iva axilaris	1	3 lbs.	Yearling lamb.	Abundant in pasture where poisoning was suspected.
Smut on carex heads	1	⅛ lb.	Yearling lamb.	
Thalesia, sp?	1	⅛ lb.	Suckling lamb.	Suspected as cause of "big head" by sheepherder.
Byanthus empetriformis	3	2 oz. to 1¼ lbs.	Sheep	Belongs to heath family, some members of which are poisonous.
Caltha, sp?	1	1.1 lbs.	Sheep	
Cassiope mertensiana	1	¼ lb.	Lamb	Belongs to heath family.
Artemisia tridentata	1	1 lb. daily for 5 days	Sheep	
Chamæsyce serpyllifolia	3	1 to 10 ozs.	Ewe and lamb.	
Veratrum californicum	2	6¼ to 8 lbs.	Calf	This plant is probably slightly poisonous.
Aconitum columbianum	1	2½ lbs.	Sheep	Probably slightly poisonous.
Delphinium cardinalis	1	1 lb.	Calf	Probably poisonous.
Asclepias cordifolia	5	⅛ to 2¾ lbs.	Sheep	Probably poisonous; less so than other species of Asclepias.
Atriplex confertifolia	2	9½ and 17¾ lbs.	Sheep and calf.	Calf lost 10 pounds in weight.
Sphæralcæ ambigua	1	10 lbs.	Sheep	

The following twelve kinds of plants have produced poisoning when fed. The toxic and lethal doses have been found to be as follows:

Triglochin maritima (Arrow-Grass).

Four sheep were fed fresh amounts varying from 1 lb. to 2 lbs. without any symptoms. Two were fed 2½ lbs. to 4¼ lbs., both being made sick, but recovered in a short time. Three were killed with amounts varying from 1½ lbs. to 2½ lbs.

Seven sheep were fed air-dried material, the amounts varying from 1 to 5 ozs. without producing any symptoms. Four, which were fed from 4 ozs. to 12 ozs., became sick, but recovered. Four were killed by amounts varying from 2¼ ozs. to 8 ozs.

Four yearling calves were fed as high as 13 lbs. of the fresh green

material in a day without producing any apparent symptoms. One yearling calf was readily killed with 8 ozs. of air-dried material.

Cicuta occidentalis.

Two horses were made most violently sick—one with 8 ozs. and the other with 15 ozs. of the tubers. For humane reasons both animals were shot. It was believed they would have died, so they were relieved of their suffering. One sheep was killed with 5 ozs. of the tubers.

Asclepias mexicana.

Two yearling calves were fed 3½ and 4¼ lbs., respectively; both were made sick, but recovered. Another yearling calf was killed with 5 lbs. of the green material, and with 12 ozs. of air-dried leaves another calf was killed.

A sheep fed first 3 ozs. and a few days later 4 ozs. of dry leaves was only made slightly sick, while another fed 4 ozs. of similar material was made violently sick, but recovered. Two sheep were each fed 5 ozs.; one was only slightly sick, the other very sick, both recovering. Two sheep were fed seeds—one 2 ozs. and the other 5 ozs.—neither of which produced any apparent symptoms.

Artemisia spinescens.

A sheep was fed 12½ lbs. of green material in 9 days, from ½ to 3 lbs. being eaten each day. No symptoms were developed.

A yearling calf was fed 9½ lbs. of green material in 6 days, from ½ to 3 lbs. each day without showing any symptoms. A yearling calf was fed 4½ lbs. in one day; became sick, but recovered in a few days. Three yearling calves were killed with fresh material varying in amounts from 4½ to 6¾ lbs.

Tetradymia glabrata.

Four yearling calves were fed amounts varying from 1 to 8 lbs. without producing any symptoms. This plant is toxic for sheep, but so far it has not been found poisonous for cattle.

Atriplex canescens.

A yearling calf was fed 2 lbs. without showing any symptoms. Three sheep fed from 2¼ to 4¼ lbs. were only made sick. Four pounds of green material were dried and then fed without producing any symptoms.

Atriplex rosea.

A yearling calf was fed 12¼ lbs. without any ill effects. Four sheep were fed amounts varying from 1¼ to 2 lbs. without any symptoms appearing. A sheep was fed 1 lb. a day for 6 days without any ill effects, but lost 7 lbs. in weight, although the animal had free access to alfalfa all the time. Another sheep fed 1 lb. was slightly sick, while another one fed 2 lbs. was killed.

Delphinium andersonii.

Six feedings were made with this plant to cattle, three being negative, the amounts fed varying from 2 to 2½ lbs. A yearling calf fed 3 lbs. was made sick, but recovered. Two yearling calves died with amounts of 3½ and 5 lbs. respectively.

Two yearling lambs were each fed 4 and 5½ lbs. respectively, both becoming sick, but both recovered.

Halerpestis cymbalaria.

A yearling calf was fed one pound, became sick, but recovered. All other feedings to cattle were negative.

A sheep fed ¾ lb. became sick, another fed 1 lb. died, and all other feedings to sheep were negative.

Solidago spectabilis.

Six yearling calves were fed amounts varying from 1 to 7½ lbs. without producing any symptoms.

Fifteen feedings were made to sheep varying from 1 to 2¾ lbs. One fed 2¼ lbs. was sick, the remainder of the feedings being negative. A sheep was fed 1 lb. a day for four days without any apparent symptoms developing.

Kalmia microphylla.

From the 10th to the 12th of July a number of feedings were made of laurel from the Sierra from King's Creek Canyon beyond Chester, Calif. Two calves were fed ¾ and 1 lb. respectively. Both became sick, but recovered. Three sheep were each fed 1 oz.; one was slightly sick, the other two showed no symptoms. Eight sheep fed from 2 ozs. to 8 ozs. all became sick, the severity of poisoning being almost in proportion to the amount fed. From July 17 to 19 three yearling calves were fed material collected near Mount Rose. One fed 4½ lbs. showed no symptoms; two fed 1 and 1½ lbs., respectively, became sick, but recovered. Ten sheep were fed amounts varying from 1 oz. to 6 ozs. Those fed from 1 to 4 ozs. showed no symptoms. Those fed 5 and 6 ozs. became sick, but recovered. On the 25th of August a sheep was fed 8 ozs. of material from near Emerald Bay, Calif. The animal was very sick, but recovered.

From September 4 to 7 another lot of material was collected from King's Creek Canyon. A yearling calf fed 6 ozs. showed no symptoms. Four calves fed amounts varying from 10 ozs. to 2½ lbs. were sick, but recovered. Four sheep were fed amounts varying from 4 to 10 ozs. The one fed 4 ozs. was sick; the one fed 10 ozs. quite sick; one fed 6 ozs. very sick, lying for five days in a stupor. One fed 8 ozs. died.

The material from near Mount Rose appeared to be less toxic than that from King's Canyon, and the last material collected from King's Canyon produced quite different symptoms than the material collected earlier from the same locality. From this it would seem that the plant varies in toxicity in different environments, and that there is a considerable seasonal change in the poisons present.

Zygadenus paniculatus (Death Camas).

Eighteen feeding tests of this plant were made to yearling calves. In two tests ¼ lb. failed to produce any symptoms; in three tests of ⅜ lb. symptoms were produced twice; in five tests ½ lb. produced symptoms twice; in two tests ¾ lb. failed once to produce symptoms; 1 lb. produced symptoms in each of the three times tried; and with another calf 1¼ lbs. failed to produce any symptoms in the one trial made.

In some of the feedings it was intended to use larger amounts, but regurgitation commenced and the feedings had to be stopped.

During the two seasons that this plant has been fed to sheep it has been found that less than ¾ lb. rarely produces poisoning symptoms, and in a few cases over 1 lb. has been fed with negative results. Sheep most frequently have been made sick with amounts in excess of 1 lb., while most of the deaths have resulted from 1¾- to 4-lb. feedings.

Zygadenus venenosus (Death Camas).

Yearling calves have been fed amounts from ⅜ to 1 lb. with negative results. A feeding of 1¼ lbs. made a good-sized yearling sick, while ⅝ lb. made a smaller-sized one quite sick.

When fed to sheep ½ lb. produced no symptoms; 1 lb. made a sheep sick and 2 lbs. produced death.

Hordeum jubatum (Fox-Tail).

This grass was found to be causing considerable mechanical injury when fed to stock, more especially sheep. During the early spring these injuries were studied in flocks of lambing ewes and the results have been published in Bulletin 97, "Don't Feed Fox-Tail Hay to Lambing Ewes."

The above summarizes very briefly the progress made with the poisonous plant project. It does not cover the hundreds of feeding tests which were made a year ago. Sufficient data are now available for at least three publications.

PROJECT NO. 20—WHITE-SAGE STUDIES

But little progress has been made with this project during the past year, due mainly to a lack of time to actively carry on the work.

This plant is one of our most valuable range plants, especially on the winter feeding-grounds. It is a plant which is rapidly disappearing on many of the intensively grazed ranges. The primary object of this investigation is to develop a system of grazing based upon the growth requirements of the plant which will build up and maintain its productivity year after year.

During the past year many germination tests have been made with the white sage. In several instances they have been highly satisfactory; in others the results have been negative. In a preliminary way the proper depth of seeding has been determined.

Until some of the other projects which are more pressing and urgent at the present time have been completed, it will be impossible to do much with this project.

PROJECT NO. 24—METHODS OF INCREASING THE PERCENTAGE OF LAMBS IN NEVADA FLOCKS

This project was commenced in 1918. It will probably take five years to work out all the details connected with it. It is quite wide in scope, involving: (1) types of bucks to be used; (2) best methods of breeding in the fall; (3) the care of the ewe while on the winter range; (4) proper feeds and handling during lambing, and (5) best methods of handling on the summer range to insure minimum loss and the most rapid and steady growth of the lamb.

The effect of the use of different grades of bucks has been practically completed, the studies covering a large number of range breeding ewes. Data are now available on the proper management and care of range ewes from the time that they are removed from the summer ranges until they are returned again. Especially valuable is the information on the proper winter care of the ewe as it affects the percentage of lambs born and reared.

Ewes have been purchased for the purpose of finding out the best feeds to use during lambing time, feeds which will stimulate an abundant supply of milk which has such a direct bearing upon the resultant spring and summer growth of the lamb.

Comparisons of gains made by lambs under different methods of handling while on the summer ranges have already been worked out.

PROJECT 23—REVEGETATION OF DEPLETED RANGES

The major part of the work which was accomplished during the past year was in connection with the proper depth to plant grass seeds in order to insure maximum germination and still permit of the seeds being planted just as deeply as possible so as to make the best use of the limited moisture supply found in the range soils.

A detailed working plan has been drawn up which will involve the following: (1) The length of time it takes the various pasture seedlings to become permanently established before being allowed to be grazed without undue injury; (2) severity of grazing which should be allowed during the first and second seasons after the pasture has been established without material loss in density of seedlings; (3) the proper height growth of the various plants which should be allowed before the grazing to secure (a) maximum yield, (b) maximum yield year after year with a minimum loss through nonuse, (c) length of time and severity of grazing which can be allowed and still secure a desirable crop for revegetation purposes; (4) the proper depth the seeds should be planted to secure maximum germination and density and least injury through pulling by grazing animals in (a) sandy soil, (b) sandy loam, (c) dry soil, (d) clay loam, (e) gravelly soil, (f) alkaline soil; (5) proper mixture of seeds to secure (a) maximum yield, (b) prolonged density, (c) best seasonal growth—spring, summer and fall, (d) greatest palatability.

The above will involve considerable time and detailed study, and in view of this it will not be possible to actively initiate this project until Projects 22 and 24 are almost complete, for they will occupy the major portion of the present personnel of this department.

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Annual Report of the Board of Control for the Fiscal Year Ending June 30, 1920

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1921

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NEVADA AGRICULTURAL EXPERIMENT STATION

I. FINANCIAL STATEMENT

C. H. Gorman

Nevada Agricultural Experiment Station

IN ACCOUNT WITH

The United States Appropriations, 1919–1920

Items	Abstract	Hatch Fund	Adams Fund
Debit			
To balance from appropriations for 1918–1919		$0.00	$0.00
Receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1920, under Acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund)		15,000.00	15,000.00
Credit	**Abstract**		
By salaries	1	$8,601.47	$9,296.45
By labor	2	1,698.32	2,154.02
By publications	3	250.59	0.00
By postage and stationery	4	194.08	2.65
By freight and express	5	46.59	44.96
By heat, light, water and power	6	310.96	0.00
By chemicals and laboratory supplies	7	85.85	281.66
By seeds, plants and sundry supplies	8	456.65	171.43
By fertilizers	9	0.00	0.00
By feeding-stuffs	10	217.58	1,467.79
By library	11	51.97	8.00
By tools, machinery, and appliances	12	847.09	43.00
By furniture and fixtures	13	33.75	23.60
By scientific apparatus and specimens	14	10.70	31.67
By live stock	15	399.48	1,167.38
By traveling expenses	16	1,109.94	307.40
By contingent expenses	17	0.00	0.00
By buildings and land	18	689.98	0.00
Balance		0.00	0.00
Total		$15,000.00	$15,000.00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Nevada Agricultural Experiment Station for the fiscal year ended June 30, 1920; that we have found the same well kept and classified as above; that the balance brought forward from the preceding year was $0 on the Hatch Fund and $0 on the Adams Fund; that the receipts for the year from the Treasurer of the United States were $15,000 under the Act of Congress of March 2, 1887, and $15,000 under the Act of Congress of March 16, 1906, and the corresponding disbursements $15,000 and $15,000; for all of which proper vouchers are on file and have been by us examined and found correct, leaving balances of $0 and $0.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said Acts, respectively.

(Signed) D. J. SULLIVAN,
State Auditor.

Attest: C. H. Gorman, *Custodian.*

II. REPORT OF DIRECTOR

Financial Resources.

With the rapid rise in prices of all commodities, the Station has experienced what is in effect a great reduction in its means of support. In recent years there has been no increase in either the state or federal funds by which it is maintained.

For many years the work has been supported almost wholly by the two federal funds, Hatch and Adams, each amounting to $15,000 per annum. For several years this income has been supplemented by a state fund of $1,000 yearly, making a total annual income of $31,000 for experimental studies of agricultural problems.

In many States a great deal of control and regulatory work has been assigned to the experiment station; and, while such work has been supported entirely by state funds, these stations have appeared to receive a far larger income than is actually expended for experimental work. In Nevada the Station has no burden of fertilizer analyses, food and drug control, or animal disease control, and the limited funds at its disposal are expended wholly for experimental studies of agricultural problems.

The recent rise in prices has in effect deprived the Station of a considerable share of its former income. Prices of labor and supplies have more than doubled, and the price of hay has risen to a point where it has seriously hampered all studies with domestic animals; supplies and apparatus for chemical and biological work have been not only high in price but frequently of doubtful quality and hard to obtain. There has been at this same time a keen demand from the State for information which could be gained only by careful experimental work. Beginning with the problem of finding a feed which would increase the milk flow of Rambouillet ewes brought in from winter ranges to lamb under shelter, a number of other problems in sheep and lamb feeding have presented themselves for solution. These problems are financially important; and if solved by experimental tests, the information gained will be of great value to the sheep-raising industry in Nevada.

The Experiment Station Farm.

Under these conditions the Station has felt a great need of additional land for sheep-feeding studies. The Experiment Station Farm of 60 acres, lying within the city limits and near the University, has for some years been used only in part by the Station.

On this farm Dean C. S. Knight, formerly Head of the Department of Agronomy and Irrigation, in College and Station, conducted a highly interesting series of experiments in variety testing and crop production. For a period of five years the farm was assigned to Dean Knight, who allotted to the Department of Dairy Husbandry a considerable area not in active use by the Experiment Station. This year the need of additional land for pasturage and silage production for sheep and for other sheep-feeding studies, and the need of much larger quantities of hay for the feeding of experimental animals, made it necessary for the Station to take over a larger section of the farm and to restrict the area allotted to other University departments.

An agreement has therefore been entered into by which all costs of maintaining the farm will be borne jointly by College and Station and each will make use of approximately one-half of the productive area.

There appears to be some reason, however, for assuming that in the near future the Station may need to use the entire farm and that even then the experimental work will be hampered to some extent by lack of land and buildings.

Accounting in the Station.

The official accounts covering the expenditures for the federal Hatch and Adams Funds are kept in the office of the University Comptroller. The system of accounting perfected by Mr. C. H. Gorman is simple and clear and has now stood the test of more than ten years' use, remaining meanwhile wholly unchanged in the face of local criticism. The great advantage of the University Comptroller's system of accounting lies in the fact that the Station accounts, like those of each subdivision of the University, are kept wholly separate from other accounts, being therefore readily accessible at all times.

These accounts, however, are classified according to federal rulings in schedules showing the nature of the expenditure made, being scheduled under separate ledger headings, such as "Salaries and Labor," "Seeds, Plants and Sundry Supplies," "Heat, Light, Water and Power," etc. These scheduled headings give information of great value showing into what classes the expenditures of the Station are falling. From an administrative point of view, however, another type of information is equally important. It is, in fact, of great value to the direction of the Station to know how much the various lines of experimental work are costing.

At the beginning of each fiscal year all the available funds are provisionally allotted to the lines of work and study to be carried on during the year, the allotments being based wholly on the relative importance of the experiments planned. Outside of salaries, these allotments are of course little more than mere estimates of the probable way in which the funds are to be expended; but it is of considerable assistance to know throughout the year how the actual expenditures correspond with the early estimates, and to know at the end of the year just what each line of work has cost.

For these reasons it has been found that an additional set of accounts kept in the Director's office is of great assistance in the economical expenditure of the funds. These supplementary accounts are classified by Station departments as "Veterinary Science," "Chemistry," etc.: but it has been found unwise to attempt to keep an account with each separate Station project. This is because the projects do not belong to any one department, but to the Station as a whole.

For example, the studies of poisonous range plants now in progress require the joint efforts of the divisions of Range Management, Veterinary Science, and Chemistry in the Station, and the domestic animals used in these studies are frequently those used in feeding experiments or even in experiments with animal disease. To assign a charge for hay or animals or labor purely to the poisonous-plant studies would often be a most artificial and arbitrary arrangement; but it has been found fairly workable to charge expenditures definitely to one or the other of the Station departments. In this matter, even, it has been necessary to use care and discretion in order to avoid making the cost of one department appear much heavier than is actually the fact. The separate accounts kept in the Director's office have been of value in keeping financial information always instantly at hand. They have

helped in solving the most difficult problem, the very evident problem of economy in the use of limited funds.

In view of the deficient buying power of the funds and because of the fact that all unexpended balances revert at the end of the year to the United States Treasury, the problem of economy takes the form of the problem of judicious expenditure. Throughout the past fiscal year every effort has been made to buy to the best advantage, paying as small prices for materials and labor as the market made possible; but it has been felt that economy consisted more than all in a close scrutiny of actual needs and the purchase of only such supplies, materials, and labor as would be of greatest assistance to the project work of the Station.

The close cooperative relation between the departments of the Station, the excellent spirit of loyal teamwork displayed, has been of great value in the economy of the Station funds.

Inventories checked at fairly frequent intervals have assisted by giving information at all times as to what apparatus and supplies are available. The sale of all apparatus and supplies for which there appeared to be no prospective use has been of assistance in keeping the laboratories supplied with articles immediately useful. The number of departments and lines of work maintained in the Station has been kept so small that it has been possible to make advances in salaries in correspondence with advances made to men of equal rank in the University as a whole. The necessity of keeping each department well supplied with labor and facilities has also been kept in mind; and the number of projects in the Station has been constantly reduced as prices rose, and to such a degree that the work done has maintained full efficiency.

Termination of Projects.

In the course of the year it became necessary to suspend three lines of project work which had been active for several years past, thus liberating funds for other purposes.

Project 15, Adams Fund, the problem of equine anemia, a disease which at times has caused the loss of large numbers of horses in Nevada, was abandoned. In recent years the disease had become very much less prevalent than it was earlier; and it appeared to be almost impossible to make much further progress toward a solution of the problem of its cause, prevention, and cure.

Since 1906 this project had been under investigation. In Nevada, as elsewhere, the study finally seemed to reach a point where only some advance in human knowledge outside the immediate field of the problem would make a solution possible. Economy of funds makes it necessary to bring to an end any line of study which goes on year after year without fruitful results, especially when the problem has ceased to be locally significant. On the other hand, great patience and tolerance should be exercised and every possible assistance should be given to continuous effort so long as it appears to promise results. In the present instance the work has been well and thoughtfully done. The problem was studied for years by the late Dr. Winfred B. Mack, later by Dr. Edward Records, Head of the Department of Veterinary Science in College and Station, and more recently by Dr. Lewis H. Wright. For several years the project has seemed to be on a doubtful basis, but

was patiently supported because of the character of the effort made by these three men.

Recently Dr. Lewis H. Wright gave the Station very valuable service by passing in review the published literature of the problem, then going over all the accumulated notes and records of thirteen years of experimental work in the Nevada Station, and finally writing up in detail in a series of papers everything of scientific interest and of local value which had not been previously covered in published reports and bulletins upon the subject. After thus summarizing the work done upon this baffling problem both in Nevada and elsewhere, Drs. Records and Wright reached the conclusion that, since no point of attack for further progressive work now presents itself, and since the disease under study is no longer of local importance, the Nevada Station is not justified in continuing work upon this project.

Project 19—Biting-Flies of Cattle. Adams Fund. This project had been carried on the active list since 1916, the work being done jointly by the Federal Bureau of Entomology of the United States Department of Agriculture and the Nevada Agricultural Experiment Station. Biological studies of the biting-flies concerned were nearly completed and remedial measures had been devised, as far as this is possible, by the close of the summer of 1919. Because of a deficiency in funds the Federal Bureau of Entomology found it impossible to continue work upon this project. Fortunately, however, the work had been pushed vigorously toward completion by Messrs. Webb and Wells of the Bureau, and it now seems probable that during the fiscal year 1920–1921 it will be possible to summarize the work done and prepare it for publication.

Project 25—Variety Testing and Crop Improvement. Hatch Fund. There were several reasons why it seemed desirable to discontinue work upon this project. In the first place, results of five years' testing had been so uniform throughout the period that they seemed relatively complete and reliable. Besides this, the project had reached a point where tests in rows and small plots should be replaced by tests on much larger areas and in different parts of the State. Moreover, the project leader, Dean Knight, who had planned these experiments and had carried them on through the five years, had resigned to take up other work. An additional reason for discontinuing the variety tests lay in the fact that all available land was required for the sheep-feeding studies in the Department of Range Management.

For these various reasons, but with much regret, the rows and plots, which under Dean Knight's skilful care had yielded information of high value, were finally abandoned and the land was prepared for other uses.

Changes in Station Staff.

On June 30, Dean C. S. Knight, Head of the Department of Agronomy and Irrigation in the Station from 1914 to 1920, resigned to accept the position of President and Managing Director of the Reno Chamber of Commerce. Mr. F. L. Bixby, of the Irrigation Division of the United States Bureau of Public Roads, was then made project leader in irrigation experiments at the Station.

Dr. Lewis H. Wright, who had been Assistant Veterinarian of the Station from April, 1918, to June, 1920, resigned to accept the posi-

tion of Associate Professor of the Division of Veterinary Medicine in the State College of Agriculture, University of Georgia, at Athens. Unfortunately the lack of funds available for publication made it out of the question for the Nevada Station to publish in full technical form the papers prepared by Dr. Wright in summarizing and terminating the Station's studies of equine anemia. An arrangement was entered into, however, by which Dr. Wright has been permitted to take with him to his new position all necessary notes and data in order that the papers may be finished and prepared for publication a little later in American journals of veterinary science.

On September 1, 1920, Mr. N. F. Peterson, who had been employed as Station Botanist and Assistant in Range Management since April, 1918, resigned to take the position of Professor of Botany in the Wayne Normal School, Wayne, Nebr. Mr. Peterson's knowledge of systematic botany and skill in identifying plants had been of great assistance to the Station; and his faithful work upon feeding experiments in Project 22, Adams Fund (Poisonous Range Plants), had been of the highest value. It is improbable that this position will be filled on the old basis in the near future unless additional federal funds become available.

Bad Effects of Lack of Funds.

Probably the worst effect of the present deficient financial support of the Station's work is the resulting narrowness of its field of activity. Every economy has been practiced. Unimportant lines of work have been abandoned, and studies of problems more closely related to engineering and forestry than to agriculture have been shifted to organizations which can handle them more legitimately.

Every possible assistance has been given to the Station by the University administration. Additional land and floor space granted by the College have been of the greatest value. The work of the Station has been narrowed down to the study of a few leading problems, most of them directly connected with the livestock industry, which is the leading feature of agriculture in Nevada. It has been the policy of the Station constantly to restrict its studies in such a way that each man employed could receive a fair salary and could be given sufficient money for facilities and labor to make his work effective. Six years ago the Station carried nearly twenty projects upon its active list. For the coming fiscal year nine projects are listed.

Important Problems Not Studied.

Meanwhile outside of the problems of the livestock industry there are many other important lines of work and study which might be of great value in building up the agriculture of the State. For the most part these studies remain wholly untouched. Nothing is being done in the study of Nevada soils; nor is the Station doing anything in horticulture. The important studies now being conducted by Messrs. Bixby and Hardman could profitably be very greatly expanded; for there is ample justification for maintaining a strong department of irrigation in both College and Station. The great problem of bringing about a more diversified agriculture in Nevada likewise remains untouched. Under present conditions it is very evidently better to pick out a few leading problems and to finance them adequately than it would be to cover a wider range of work; but it is evident that the station is greatly in need of additional support.

Need of Additional Federal Support.

Further funds may perhaps ultimately be obtained from either of two sources. It may be possible to secure some assistance by direct appropriation on the part of the Nevada Legislature. However, the high cost of maintaining the necessary functions of state government in a State where a small population is scattered over an immense area, and where the total taxable property is necessarily small, has naturally led the University to ask support only for lines of work most vitally needed. Moreover, experimental work is often with difficulty supported by state funds. The fact that experiments in many fields are often fruitless, no matter how well planned, and that they must often be maintained on the same basis through a long period of years before any conclusion can be reached, will always make support by state funds precarious. The significance of a given line of experiments may be clearly appreciated by the members of one Legislature. The next Legislature may fail to see the need, or may be impatient because of the lack of immediate results from the previous grant. Again, the work may be well supported during a term of years, and then a sudden period of financial stringency or of greater needs along other lines may bring it to an abrupt and disastrous termination.

The second possible source of relief, an increased grant of federal funds, is on the whole much to be preferred where experimntal work has to be continued through a considerable period of years. Federal support is far less apt to fluctuate in amount; and lines of work once established under federal funds can usually be carried through to a legitimate conclusion without question or interference.

For example, the Station's studies of the protective relationship of timber to snow and of methods of snow-surveying were begun by Dr. J. E. Church under the federal Adams Fund in 1906 and continued through 1916. Conclusions of the utmost value were reached and a method of snow-surveying was worked out by Dr. Church and his associates, Messrs. Ferguson and Smith, which has found wide application in western America, in Canada, Norway, and Switzerland—in fact wherever the relationship of accumulated snowfall to irrigation, power development, or water storage is under study. This example is the more noteworthy in view of the fact that early in the history of this project it became evident that these studies were more closely related to engineering and forestry than to agriculture. Once laid down, however, the plan was carried through to a conclusion; and, except for a single year, the work received generous support from federal funds during the entire ten-year period.

An additional reason for federal, rather than state, support lies in the fact that all successful experimental work is of far more than local importance.

For example, the studies of poisonous plants now in progress in the Nevada Station have awakened great interest throughout the Western States and Canada. Bulletin 95, Range Plants Poisonous to Sheep and Cattle in Nevada, published in July, 1918, by the Nevada Station, promised to be of so much use in other States that hundreds of copies were requested by parties in California, Utah, Colorado, and other Western States. Through an agency of the Federal Government 500 copies were distributed in South American countries. Although an edition of 5,000 copies was published by the Station, practically none

now remain for distribution. The cordial reception of this bulletin and the evident usefulness in other regions illustrated clearly the fact that practically all experimental work is of great importance outside the State in which the studies are made. The support of such studies by federal funds is therefore particularly appropriate. Under present financial conditions it seems highly desirable that every effort be made to secure soon a large increase in the Hatch and Adams Funds.

Active Projects of the Nevada Station and Progress Made During the Year.

Project 2—Variety Testing and Crop Improvement. Hatch Fund; 1914–Continuous. Project Leader, C. S. KNIGHT. Throughout the summer of 1919 work upon this project was continued along the lines previously laid down. As planned originally by Dean C. S. Knight, this project contemplated a test of cereals, forage crops, and silage crops both in rows and in plats to find the varieties of these crops which are specially adapted to local conditions because of their hardiness and yielding capacity and to improve these varieties through selection. The best varieties were to be tested further in various parts of Nevada where the altitude and climatic conditions differ from those near Reno.

Tests of sixteen varieties of wheat through the six-year period, 1914–1920, showed that in rows White Club was the highest producer. In three seasons' plat tests it was also the highest producing variety of wheat. Next in order came Galgalos Fife, Chul, Colorado Fifty, New Zealand, and Marquis, with yields not much below that of White Club. An important point brought out in row and plat tests of wheat is the fact that under judicious irrigation both Marquis and Blue Stem continued to produce a high quality of wheat for milling purposes. Marquis commands a premium at the mills which more than offsets its somewhat lower yield.

In a five-year test, Early Mountain oats headed the list by a good margin, its production being nearly double that of the lowest yielder. Early Mountain is less affected by shattering than other varieties.

As in several previous years, Swedish Gold barley led the list in the row tests. In field tests, however, it has failed to make good; largely because of the short straw, which makes it difficult to save all the grain with the binder. This fact will probably prevent the introduction of the variety on a commercial basis. In plat tests covering two seasons, Blue Ribbon barley gave better results than either Swedish Gold or Manchuria.

As noted in previous reports, the Russian sunflower gave a heavier yield of silage than either the improved Leaming corn or Sudan grass. The average production of sunflowers for three acres was at the rate of 20 tons per acre, while that of improved Leaming corn was approximately 12 tons.

Project 25—Irrigation Investigations and Crop Improvement on the Humboldt River. Hatch Fund; 1919–1924. Project Leaders, C. S. KNIGHT (1919), F. L. BIXBY (1920). In 1918 the work was outlined as a cooperative project between the Nevada Station and the Irrigation Division of the United States Bureau of Public Roads, Dean C. S. Knight representing the Experiment Station and Mr. F. L. Bixby the Irrigation Division. After careful study of conditions along the upper Humboldt, Messrs. Knight and Bixby decided that it would be best to undertake work upon this project farther down the river where flood

conditions are less severe and the flow of water is under better control. Fair conditions for this project were found on the holdings of the Land Development Company at Battle Mountain. The work laid out involves a study of the possibility of crop improvement through changes in method of irrigation. The principal features of this project are studies of the effect of methods of irrigation and quantities of water upon crops and soils.

It is frequently stated that overirrigation of the wild-grass meadows along the Humboldt River greatly injures the quality of the hay. It is also frequently stated that, by suitable methods of handling land and water, alkali conditions in Humboldt Valley soils can be greatly improved.

In the course of the year soil and moisture studies were made on the tracts chosen, and it was found that water penetrates these alkali soils rather more rapidly than had been supposed and that the drainage was excellent. On the alfalfa and grain land the soil showed a moisture-holding capacity of approximately 35%.

Field work on this project was done by Mr. Geo. Hardman, who established headquarters at Battle Mountain and took general charge of the work. From the beginning a great many difficulties have been encountered, the most serious one being the unreliability of the water supply. This made seeding with sweet clover and alfalfa exceedingly difficult; and the lack of water during the germinating season spoiled a number of promising tests. A good deal of valuable information was obtained, however, particularly in connection with methods of applying water to the land; and, as the difficulties encountered were typical of lands along much of the Humboldt River particularly in dry seasons, the work should in the long run be all the more significant.

Project 23—Revegetation of Depleted Ranges. Hatch Fund; 1916–Continuous. Project Leader, C. E. Fleming. Experimental studies of revegetation of depleted ranges made less progress than the Station's studies of poisonous range plants. It has, in fact, become more apparent every year that the revegetation of the open public range is hopeless. There appears to be not the slightest prospect of any method of treatment which will improve conditions on ranges not under control. Just so long as stock are ranged at will on the open public ranges, the grasses and other forage plants growing there will be eaten off too frequently and severely and at the wrong season.

There is every reason to fear that the open range will decrease steadily in Nevada in value as grazing ground. There is probably no other problem of greater importance to Nevada agriculture than this. Much of the hay land in Nevada is valuable only because of adjacent range. There are thousands of acres of fertile soil in the State perfectly capable of producing potatoes, onions, celery, peas, sugar-beets, or other crops of high value, yet these lands are in hay and must be kept in hay simply because of marketing and transportation conditions. These lands are now used with profit as sources of stock feed; but, with the impoverishment of the ranges, a condition is certain to come about where the farm lands of the State will decrease in value and the population of Nevada may grow smaller.

The Station's projected study of revegetation of range lands has thus far led straight to the conclusions given above, and work upon the project itself will now be almost suspended up to the time when

the University shall succeed in securing for these studies, by suitable federal enactment, a large tract of representative range land where experiments in range improvement can be made under complete control in cooperation with Nevada stockmen.

Project 24—Lamb Production in Nevada. Hatch Fund; 1919–Continuous. Project Leader, C. E. FLEMING. This project is a study of a number of closely related problems in lamb production. For several years large sheep-owners have been bringing in more range ewes to lamb under shelter. Some elaborate and highly expensive structures have been put up for this purpose in different parts of Nevada, but, on the whole, the results have been somewhat disappointing. The great difficulty seems to be in the character of the feed supplied to the ewes under these conditions, as there appears to be little or nothing available as feed except alfalfa hay, wild-grass hay, and a limited amount of grain. Thus far, on these dry feeds the ewes have often given an insufficient milk supply, a statement particularly true of the Rambouillet breed.

Mr. Fleming therefore planned to test various supplementary feeds which can be grown in Nevada, to determine their effect on the milk flow of ewes. The tests were made with small numbers of animals; and the results secured cannot be wholly accepted because they include only a single year, yet the experiments give every indication that it is quite possible by suitable feeding to solve this entire problem. At the earliest possible date, as soon as safe conclusions have been reached, the results will be published in bulletin form and distributed throughout the State.

Sunflower Silage. In this connection Mr. Fleming tried an unusually interesting experiment in silage production. Two small silos of redwood staves, each holding 3½ tons, were filled with sunflower silage in the summer of 1919, the only variation from the usual method being in the method of fermentation. After packing, it is well known that silage ferments much as does sauerkraut. In past years in western Nevada this fermentation of sunflower silage has produced various results. From some silos a fair grade of silage was produced. From others the silage was dark and of very bad odor. In some instances it was so plainly unfit for feeding that it was put back on the land as manure.

After reading an article which appeared in the Country Gentleman in the summer of 1919 upon the fermentation of corn silage with sour milk, we decided that it would be well worth while to attempt the fermentation of sunflower silage by this means; the idea being that if a standard dairy "starter" or culture of bacteria was employed in sufficient quantity, then the whole contents of the silo would probably be fermented promptly by this organism. By this method it should be possible to produce year by year a standard grade of silage. With the cooperation of the Department of Veterinary Science in the Station, a large quantity of milk soured with standard dairy starter was produced and was sprinkled through the sunflower silage as it went into the silo. Fermentation took place at once and was apparently very effective.

When the silo was opened in February, 1920, the silage appeared unusually bright and clean. The yellow ray flowers of the sunflower were still bright yellow; there was not the slightest discoloration

against the stave walls; the odor was pleasant and refreshing, much like that of a good grade of pickles. The flavor of the sunflower pith was pleasantly acid and agreeable. In the course of the coming fiscal year a large silo will be put up and soured with sour milk as in this test. One of the two smaller stave silos will be filled with sour-milk silage. while the other will be filled without any "starter." Similar tests will be made in succeeding years and these tests should show conclusively whether the sour-milk method is of value, and whether a thoroughly good grade of sunflower silage can readily be put up in Nevada. If this proves to be practical, then feeding experiments may perhaps show that in Nevada sunflower silage can be made to play the same part in lamb production that corn silage plays in parts of Idaho and other States.

Project 26—Feeding and Finishing Range Ewes and Lambs. Hatch Fund; 1920–Continuous. Project Leader, C. E. FLEMING. This is a new project, its purpose being to find out whether under Nevada feeding conditions it is desirable to finish lambs and aged ewes prior to shipment. This is of course a question of costs; and data will be obtained showing the cost and the profit or loss of feeding and finishing both ewes and lambs before they go to eastern markets.

Project 27—Pasturage and Silage Production for Sheep. Hatch Fund; 1920–Continuous. Project Leader, C. E. FLEMING. A portion of the Station Farm will be put into permanent pasture, various grasses and grass mixtures being tested for the purpose. The cost and productiveness of such pastures will be worked out. Both corn and sunflower silage will be grown in sufficient quantities to give fair grounds for a comparison of yields. Experimental tests will be made of various methods of growing sunflowers for silage. Tillage, manuring, and soils will be tested in sunflower-silage production.

Project 16—An Unidentified Hemorrhagic Disease in Cattle. Adams Fund; 1914–Continuous. Project Leader, DR. EDWARD RECORDS. This project is a study of a disease of cattle closely resembling anthrax in many of its symptoms. It causes the death of many cattle every year in western Nevada. It is, however, quite distinct from anthrax, with which it was probably confused at an earlier date; and it causes a considerable annual loss, frequently of valuable animals. Work upon this project was begun in 1914 by the late Dr. W. B. Mack, who was greatly interested in the subject and who pursued its study with all his customary energy and enthusiasm. No solution was found, however; and in 1918, after the death of Dr. Mack, his successor, Dr. Edward Records, took charge of the project and has since continued the work with painstaking thoroughness. Every effort has been made to discover the bacterium or other micro-organism which causes the disease, but thus far all efforts have proven almost fruitless.

Since the disorder resembles hemorrhagic septicemia in many of its symptoms, an antihemorrhagic septicemia serum was prepared and was administered to a very large number of animals. Up to December 31, 1919, 25,552 animals were vaccinated with the double form of bacterin-vaccine adopted early in the work on this project. Concerning the protective influence of this treatment, Dr. Records states that, "In general, the ranchers appear to be of the opinion that this form of vaccination has lessened the incidence of the disease, but a more critical examination of the results would indicate that this is not

the case." Dr. Records states that a favorable result should not be expected, since it has never been shown that the organism causing hemorrhagic septicemia is the cause of the disease under study.

Early in the spring of 1919 the members of the Department of Veterinary Science decided to make a very careful test of an interesting theory which had been proposed to account for the occurrence of this disease. According to this theory it seemed possible that the disease might be not due to any bacterial infection, but might be caused by some form of plant poisoning. In other countries diseases of much the same type have been caused by certain plants belonging to the sunflower family, in the genus known as *Senecio*. Throughout the summer, therefore, every effort was made to account for the occurrence of this disease by the fact that the animals in question had eaten poisonous plants. However, careful field studies by the Department of Range Management showed that, on many of the lands where the disease occurs most frequently, soil and water conditions are such that plants of the *Senecio* group will not grow there. Moreover, in a direct experimental test, a cow weighing approximately one thousand pounds was fed 25 pounds of *Senecio* without effect. Toward the end of the year this theory of plant poisoning was largely abandoned; and Dr. Records, with his new assistant, Dr. Vawter, resumed the old line of study, the investigation of the bacterial origin of the disease.

Project 19 — Biting-Flies of Cattle. Adams Fund; 1919–1921. Project Leader, S. B. DOTEN, Nevada Station, and R. W. WELLS, United States Department of Agriculture. This project was discussed in detail earlier in the present report, and, as the work upon it will probably be published in full in the course of the coming fiscal year, further discussion will be left to await publication.

Project 20—White-Sage Studies. Adams Fund; 1916–Continuous. Project Leader, C. E. FLEMING. The same conditions which have made it extremely difficult to continue revegetation studies on the open range have to a large extent hampered progress in the study of the white-sage ranges. However, a small patch of white sage growing on a knoll on the Experiment Station Farm has made it possible to study in some detail the conditions which are favorable to the growth and reproduction of the plant.

Project 22—Poisonous Range Plants. Adams Fund; 1916–Continuous. Project Leader, C. E. FLEMING. When work was begun on this project in 1916 it seemed apparent that local conditions afforded an unusually good opportunity for the study of the problem. Within easy reach of the University, on adjacent mountain ranges, practically all of the poisonous plants known to occur in the West can readily be obtained in quantity.

When the experiments were first planned it was thought that there were not more than half-a-dozen poisonous plants of local importance and that their study would readily be finished in a few years. However, as the work progressed it was found that the importance of the subject was far greater than had been anticipated; and a little study made it evident that under Nevada conditions losses due to poisonous plants are far more serious than those caused by all forms of animal disease taken together. Besides this, it soon became clear that instead of a half-dozen plants there are 12 or 14 which cause loss, several of which had not previously been considered poisonous. Many difficulties

likewise were encountered in feeding the animals upon the poisonous plants and in so planning the experiments that the results would give evidence of value.

In earlier years the Nevada Station had given considerable study to the problem of plant poisons; and some notable work had been done by Dr. C. A. Jacobson, Research Chemist, upon the active poisonous principles found in the poison parsnip, death camas, and other poisonous plants. It seemed best, however, to recast the entire plan of study and to approach the subject from another angle. Evidently the method which would give information of the highest value would be a method based on actual feeding tests with range animals. The most significant facts are the answers to the following questions: (1) What effect does the plant have when eaten by an animal? (2) how much does it take to make an animal sick or to kill it? (3) under what conditions and at what time of the year is the plant dangerous? (4) what part of the plant is poisonous? (5) what kind of animals will it poison? (6) what can be done about it?—that is, can animals be so handled on the range that they will not eat the poisonous plants, or is it possible, under certain conditions, with some of the plants, to dig or fence them and otherwise prevent them from causing loss?

Work upon this project has progressed steadily since 1916; and while the work has been constantly under the leadership of Mr. C. E. Fleming, Head of the Department of Range Management, many important aspects of the subject have been studied in other departments.

For example, Mr. M. R. Miller, Head of the Department of Chemistry in the Experiment Station, has given most faithful and intelligent study to the nature of the poisonous principle found in each of the deadly range plants. Good progress was made in the course of the year toward the isolation of active poisons from a number of range plants, and the work done has thrown a good deal of light on the character of the symptoms displayed by the poisoned animals.

The Department of Veterinary Science has also added very valuable information to the work done upon this project by recording the symptoms shown by the poisoned animals, and studying the effect of the poison upon various bodily organs in post-mortem examinations. On the whole, the results of experiments conducted this year upon this project agree fully with similar work done here in past years in emphasizing the great importance of handling animals on the range in such a way that poisoning will be less apt to occur.

Project 12—Methods of Snow-Surveying. 1906–1917. Project Leader, Dr. J. E. Church. This project was discontinued in the Nevada Experiment Station in 1917 because snow-surveying had then reached a point where the investigation was completed and little more could be learned about the method except through its use on a large scale in the field. It seemed highly desirable to test the method widely over a large area, and in the course of the last few years this has been done by Dr. Church, through the cooperation of the State Department of Engineering of the State of California.

Without in any way reflecting upon other significant and important work done here in recent years, it is only fair to say that in the long run in the Nevada Station few other lines of experimental study are likely to prove more fruitful than the studies which led up to Dr. Church's method of snow-surveying.

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Annual Report of the Board of Control for the Fiscal Year Ending June 30, 1921

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1922

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NEVADA AGRICULTURAL EXPERIMENT STATION

I. FINANCIAL STATEMENT

C. H. Gorman

Nevada Agricultural Experiment Station

IN ACCOUNT WITH

The United States Appropriations, 1920–1921

Items—	Abstract	Hatch Fund	Adams Fund
Debit			
To balance from appropriations for 1919–1920		$0.00	$0.00
Receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1921, under Acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund)		15,000.00	15,000.00
Credit			
By salaries	1	$8,417.15	$9,986.61
By labor	2	2,201.00	1,977.70
By publications	3	650.39	0.00
By postage and stationery	4	263.91	68.82
By freight and express	5	119.62	144.34
By heat, light, water and power	6	156.20	189.11
By chemicals and laboratory supplies	7	1.25	167.83
By seeds, plants and sundry supplies	8	394.68	128.37
By fertilizers	9	0.00	0.00
By feeding-stuffs	10	425.20	340.48
By library	11	53.57	53.79
By tools, machinery and appliances	12	787.87	73.28
By furniture and fixtures	13	66.30	2.50
By scientific apparatus and specimens	14	35.08	2.00
By live stock	15	105.75	1,588.85
By traveling expenses	16	774.40	276.32
By contingent expenses	17	0.00	0.00
By buildings and land	18	547.63	0.00
By balance		0.00	0.00
Total		$15,000.00	$15,000.00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Nevada Agricultural Experiment Station for the fiscal year ended June 30, 1921; that we have found the same well kept and classified as above; that the balance brought forward from the preceding year was $0 on the Hatch Fund and $0 on the Adams Fund; that the receipts for the year from the Treasurer of the United States were $15,000 under the Act of Congress of March 2, 1887, and $15,000 under the Act of Congress of March 16, 1906, and the corresponding disbursements $15,000 and $15,000; for all of which proper vouchers are on file and have been by us examined and found correct, leaving balances of $0 and $0.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said Acts, respectively.

(Signed) D. J. SULLIVAN,
State Auditor.

Attest: C. H. Gorman, *Custodian.*

II. PROJECT LIST

HATCH FUND

IRRIGATION:

Project 25. *Methods of Increasing Hay Production in the Humboldt Valley, Nevada.* 1919–1924. Project Leader, F. L. Bixby.

RANGE MANAGEMENT:

Project 23. *Revegetation of Depleted Ranges.* 1916–Continuous. Project Leader, C. E. Fleming.

Project 24. *Lamb Production—Methods of Producing More and Better Lambs in Nevada Range Flocks.* 1919–Continuous. Project Leader, C. E. Fleming.

Project 26 (new project). *Feeding and Finishing Range Ewes and Lambs.* 1920–Continuous. Project Leader, C. E. Fleming.

Project 27 (new project). *Pasturage and Silage Production for Sheep.* 1920–Continuous. Project Leader, C. E. Fleming.

ADAMS FUND

VETERINARY SCIENCE:

Project 16. *Hemorrhagic Disease in Cattle.* 1914–Continuous. Project Leader, Dr. Edward Records.

ENTOMOLOGY:

Project 19. *Biting-Flies of Cattle.* 1916–1921. Project Leader, S. B. Doten.

RANGE MANAGEMENT:

Project 20. *White Sage Studies.* 1916 – Continuous. Project Leader, C. E. Fleming.

Project 22. *Poisonous Range Plants.* 1916–1918 (Hatch). 1918–Continuous. Project Leader, C. E. Fleming.

III. REPORT OF THE DIRECTOR

Work Now in Progress in the Experiment Station.

It will be seen from the project list given on the preceding page that the principal lines of work now in progress in the Nevada Station are: (1) the study of the economical use of water in irrigation; (2) studies of insects injurious to alfalfa and other crops; (3) studies of certain animal diseases; and (4) the study of problems of range management. To any one familiar with Nevada conditions the importance of these projects is clearly evident.

In the last five years the need of rigid economy made it necessary to cut out from the station program all lines of work except those based upon an actual demand for information coming from the agricultural industries in the State. The present project list is founded on an active demand for information to assist in solving problems in farming and stock-raising.

Studies for the Development of Special Industries.

It is evident from the project list that at present the work of the Station is based upon the type of agriculture which has developed naturally in Nevada, and that the studies in progress will be of especial assistance to the State's great livestock industry. Still, it is well to keep in mind the fact that there are other agricultural industries developing in Nevada which are very promising and which should receive encouragement. It has often been stated that it would be very desirable for the Station to give active assistance toward the development of such minor agricultural industries as sugar-beet raising, the poultry industry, dairying, orcharding, and the like.

However, work in each one of these fields would require the employment of men of special training and the purchase of additional equipment. The funds provided for station work in Nevada are very limited. The federal funds are precisely the same as in 1913. Under these conditions it is necessary to take up for study the problems of the most important lines of present-day agricultural production in the State and to finance these problems adequately as station projects, excluding for a time work on problems of less importance. Nevertheless, wherever it is possible, advice and assistance are freely given toward the development of special industries which are not yet financially important.

Effects of the Present Lack of Funds for Experimental Work.

In 1921, just as for many years past, the Station was supported almost wholly by the two federal funds, Hatch and Adams, each amounting to $15,000. The yearly total of $30,000 is supplemented by a small state fund amounting to approximately $1,000 each year.

Under these limitations, the restriction of station projects to the study of problems of the livestock industry is not the only way in which the lack of funds affects the Station, for even the lines of work now actually in progress can scarcely be adequately financed. For example, one of the outstanding problems in Nevada agriculture is the problem of using the existing water supply in the most economical way in crop

production. The present plan includes studies of the economical use of water on crops in the Humboldt Valley. Similar studies have been made in the vicinity of Reno, and work of the same kind is to be carried on later in other parts of Nevada.

The water problem is evidently a very large and important one. It has many engineering features, studies of ditch construction, and of special methods of handling water on peculiar soils; studies of the development and use of underground water, and the like.

The fact is that, if both the Hatch and Adams funds could be wholly expended in this one field of work, the total sum now available for the support of the Station would not do more than adequately to provide for this single set of projects.

Again, the Division of Range Management is in much the same condition as the Division of Water Studies. Excellent work is being done, work whose value is recognized throughout the West; and yet the total sum expended in this field amounts to less than $10,000 annually. Recently several large companies owning enormous tracts of range land have offered their full cooperation in the study of range management. If funds were available, the Station would be only too glad to develop this opportunity for cooperation and to undertake the actual management of large tracts of Nevada range with the view of developing improved methods of management which should make such controlled areas far more productive than they are now. The importance of such studies can scarcely be overestimated, yet our limited funds make it out of the question to undertake them at present.

Evidently the work in Range Management might profitably be greatly extended; and, just as with the water studies, all the available funds of the Station could well be expended upon the Range Management projects alone.

What the Experiment Station Cannot Legitimately Do.

There is a constant and growing demand for assistance from the Experiment Station outside of its legitimate field of activity. We have said that the existing funds are at the best wholly insufficient fully to finance the Station's project work. In spite of this fact there is a constant call for work lying outside this field, work which cannot legitimately be paid for under the restricted federal funds.

There seems to be a very general impression that an experiment station is an official information bureau which should be always ready to furnish information of astonishing variety. Almost every mail brings requests from commercial organizations manufacturing special products for a detailed list of facts concerning agricultural organizations, methods, and production in Nevada. Requests are received almost daily for copies of state laws concerning the marketing of fertilizers and other products.

Even these requests are more legitimate than many which come both from Nevada and from closely adjoining States. Every little while we get samples of very doubtful rock, probably not richer than a backyard grindstone, with the request that the Station provide assays for gold, silver, or almost any other mineral. Soil and water samples are sent in for analysis; it is a common thing to receive samples of soil that could be scarcely expected to grow anything, with the request that

we furnish detailed information concerning crops which can be made to grow in such soil and the best methods of growing them.

Now the actual fact of the matter is that, even if the sample represents the soil of a field or a farm, a thing quite unusual, because it takes considerable experience and skill to obtain a representative sample, even then a chemical analysis would be only a very doubtful guide to the kind of ;crops which the soil could be expected to support. About the only soil test which is worth anything is a trial by the actual planting of crops under normal conditions in selected plots on the ground for one or more seasons.

Sometimes the Station receives other requests of a still more curious nature. A letter received from a man in Kansas stated that he was having domestic difficulties and that he planned to come to Reno for the typical short sojourn; he asked the Director, apparently as a friend of all farmers, to try and find him a job and to give him the name of an attorney whose advice could be relied upon and whose charges would be moderate!

The established policy of this station in regard to all requests for information, particularly those coming from Nevada people, has been to do everything possible to give the assistance desired. All requests for general information from Nevada farmers are kept in a special file. These letters are answered with particular promptness, and in a way to make the information given complete and helpful. Hours are sometimes spent in the preparation of answers to letters of this kind. This policy has been followed simply because any failure to answer these letters from Nevada farmers promptly and in a serviceable way would be bound to make enemies for both the Station and the University; while, on the other hand, prompt and effective answers make friends and react strongly in our favor. Still, it would seem that the time has gone by when all this should be necessary. The farmers of the State should from now on take up all general agricultural questions with their county agents; then, if there is anything unusual in the problem, the county agent should take the matter up with the Experiment Station.

Control Demonstrations in the Field Cannot Be Paid For from Station Funds.

In the case of outbreaks of well-known insect pests or plant diseases the question is sometimes asked: Why does not the Experiment Station undertake a campaign of control? The answer is that it is the function of the Station through its experiments to work out methods and means of control; but after these methods have been worked out, either in this State or elsewhere, the Station would go outside its legitimate field if it were to undertake campaigns of control. Such campaigns are expensive; and, as they belong fully to the Extension Service, the restricted and depleted funds of the Station are not used for this purpose.

The alfalfa-weevil situation furnishes a striking illustration of the matter. This insect is present in alfalfa fields near Reno, and will in time be spread from Reno to alfalfa in other parts of Nevada and perhaps to California. Thoroughly tested methods of control have been fully worked out in Utah and in other States. It has been shown that control through spraying is not difficult, being in fact cheaper

and more effective than with many other insects. Under the regulations governing the federal funds the Station has no right to undertake field demonstrations of the known methods of controlling this pest. The field of the Station is research, through experiments to discover methods of control; the application of the methods of control and campaigns of education along these lines must rest with the Extension Service and the farm bureaus.

On the other hand, in this case as in all others, the Station stands ready to put all existing information at the service of the Extension Division and the farm bureaus and to furnish advice concerning the well-known methods of control. In the case of the alfalfa weevil, Extension Director Cecil W. Creel has planned from the beginning a series of control campaigns, working, of course, through the local farm bureau organization. Even at that, as is pointed out further on in this report, the need of active control campaigns will not be great for several years; and meanwhile the Station is attempting to hamper and delay the spread of the weevil through the introduction of parasitic insects which prey upon it.

Relations of the Station with the Extension Service and the Farm Bureau.

The alfalfa-weevil situation brings out rather clearly the relations existing between the work of the Station and that of agricultural extension. The Station selects for study problems in the local agriculture and attempts to work out a solution. Some of the problems may concern feeds and feeding, others the use of water in crop production, others insect pests and plant diseases; but the governing condition is that the problem at the outset shall not have been solved elsewhere, that methods of control shall not yet be known, and that the Station shall make an organized attempt to find practical methods which can be used under local conditions.

If the effort is successful and a practical method is devised, then the Extension Service, or such agencies as the State Veterinary Control Service, working through county agents and farm bureaus, will undertake to teach farmers in the field how to solve the problem.

Very evidently this makes necessary the closest cooperation and cordial relationships between the Experiment Station and the Extension Service. Moreover, since the Extension Service touches every nook and corner of the State, the Station should be always willing to be guided in part by the Extension Service in its choice of problems and in the location of its studies.

In this connection it is only fair for the Station to extend at this point its hearty thanks for advice given in the past and assistance rendered by the Extension Service, whose former Director, Charles A. Norcross, and whose present Director, Cecil W. Creel, have shown full appreciation of the value of station work in progress and a clear understanding of the limitations of the federal funds, while at the same time giving helpful advice as to lines of work which might best be pursued. They have constantly given the station men special opportunities and facilities for coming into intimate contact with the farmers of the State and with their problems.

Relations of the Station with the University.

The Chemical Laboratory. In the course of the present fiscal year it became evident that the office and laboratory long occupied by the

Experiment Station in the Chemistry Building are greatly needed for the instruction of students in chemistry, and that it will be necessary to provide other quarters for the Station's research work in this field.

Through the kind cooperation of Dean Robert Stewart of the College of Agriculture, half of the soils laboratory in the basement of the Agricultural Building was given to the Station for its new chemical laboratory; and in addition another basement room was set aside for the grinding of samples, the storage of supplies in bulk, and other purposes. It will be necessary to partition off the space to be occupied by the laboratory and to install an entirely new equipment of chemical desks, shelving, and sinks. All wiring, plumbing, and other facilities will be new. Mr. M. R. Miller, head of the Department of Chemistry in the Station, has drawn a full set of plans showing every detail of the construction of the new laboratory. The chemical benches, shelving, and lockers will be of standard type, being modeled for the most part after types now in use in the University of California. The cost will naturally be heavy; but it is planned to meet it almost entirely from state funds. When the work is done the new laboratory will be most conveniently arranged, well lighted and heated, and excellently adapted to its purposes.

The Experiment Station Farm. Last year this farm was used jointly by the University and the Station; but at the beginning of the present year it became evident that if the Station is to conduct elaborate experiments in the pasturing and feeding of sheep, and raise pasturage, sunflower silage, and alfalfa hay for all the experimental animals in veterinary science and range management, then it must have more land.

In the same kindly spirit of appreciation which has been shown by the University administration toward the Station for many years, President Clark gladly set aside the previous arrangement for joint use and permitted the Experiment Station to use the whole farm for its purposes.

The entire area was therefore turned over to Mr. C. E. Fleming for his work in range management, with the exception of corrals and sheds used in experimental work in veterinary science.

PUBLICATIONS

The following publications appeared in the course of the year, covering various phases of the work of the Nevada Station:

Annual Report of the Board of Control for the Fiscal Year Ending June 30, 1920. By S. B. Doten. 16 pages.

Bulletin No. 99. The Narrow-Leaved Milkweed and the Broad-Leaved or Showy Milkweed. By C. E. Fleming, N. F. Peterson, L. R. Vawter, and L. H. Wright. 32 pages.

This bulletin is based wholly on feeding experiments with these plants conducted at the veterinary field laboratory of the Experiment Station by Mr. Fleming and his associates. The plants are described, their habits of growth and means of spread are discussed, and an account of the feeding tests is given, including the quantities of the plants which were fed, the symptoms shown by poisoned animals, the conditions under which milkweed poisoning occurs, and the methods

by which losses may be avoided. Ten original photographs and drawings are used as illustrations.

Bulletin No. 100. The Poison Parsnip or Water Hemlock. By C. E. Fleming, N. F. Peterson, M. H. Miller, L. H. Wright, and R. C. Louck. 23 pages.

This bulletin, like Bulletin No. 99, is a detailed illustrated account of the appearance of the plant, the situations in which it grows, its means of spread, conditions under which poisoning occurs, symptoms, and methods of prevention. It is founded purely on our own experimental work. Illustrations—1 color plate after water-color by Miss Martha Ryan; 10 original photographs and drawings.

Bulletin No. 101. Death Camas. By C. E. Fleming, N. F. Peterson, M. R. Miller, and L. H. Wright. 31 pages.

This is a detailed descriptive account of the experimental work done with this plant by Mr. Fleming and his associates, similar in form to the two preceding bulletins on poisonous plants. Illustrations—12 original photographs, 1 drawing.

The Internal Parasites of the Horse in Nevada. By L. H. Wright. (Journal of the American Veterinary Medical Association, June, 1921.)

An account of the various worms and maggots found in the stomach, intestines, and circulatory system of horses in Nevada, together with an account of methods of treatment. Based on Dr. Wright's experimental work while he was connected with the Nevada Station. One illustration.

Necrobacillosis in Dam and Calf. By L. R. Vawter. (Journal of the American Veterinary Medical Association, June, 1921.)

This is an account of Dr. Vawter's observations of a fatal case of nodular necrosis of the liver in a dairy cow, with fatal infection of the same type taking the form of a general septicemia in her calf. Not illustrated.

The Alfalfa Weevil Situation in Nevada. By S. B. Doten. (The Nevada Stockgrower, June, 1921.)

This is an account of the spread of the weevil in western Nevada, the territory now occupied, the damage done, and proposed methods for control through farm bureau organizations and the work of the county agents of the Agricultural Extension Service. It includes a brief account of the introduction of parasites of this insect by the Experiment Station in cooperation with the federal Bureau of Entomology. Not illustrated.

PROGRESS MADE DURING THE YEAR ON STATION PROJECTS

Project 22. The Problem of Poisonous Range Plants.

Throughout the year reports coming in from stockmen indicated that losses from poisonous range plants have not lessened, but are increasing with the steady depletion of the range. Experimental studies of these plants continued throughout the year. Feeding tests, largely to sheep, were made with lupines, rabbit-brush, bud-sage, mountain laurel, saltbushes, and buttercup; no further tests with larkspur were made, but they will be made in the near future when some of the other work is cleared up. In the course of the year Mr. Fleming made 231 separate

feeding tests. These showed clearly that all the plants under test have poisonous properties, with the possible exception of certain lupines, none of which proved poisonous to the sheep. The experiments went a long way toward showing what amount of each poisonous plant will cause sickness, and how much is required to cause death. Observations and notes were made upon the conditions under which poisoning occurs and the methods of handling stock by which losses may be avoided.

Rabbit-Brush (*Tetradymia*), *A Cumulative Poison.* One interesting outcome of Mr. Fleming's tests was a clear proof that the poisonous property of the common shrub called rabbit-brush (*Tetradymia*) is not at once thrown off by the animal's system but will accumulate for days in small quantities until it finally causes sickness or death. This is the only poisonous range plant which we have tested thus far which

Figure 1. Feeding-Pens for Sheep Experiments.

Figure 2. Lamb Eating Sunflower Silage.

has this peculiar property. The others either make the animal sick at once or else fail to cause any symptoms, even though fed in small doses for many days.

In connection with Mr. Fleming's feeding experiments, very careful chemical work is in progress upon the active poisonous principles of the dangerous range plants. It is expected that this work will confirm the conclusions reached by the feeding experiments, and will throw light upon the nature of the symptoms shown by the poisoned animals. Only in exceptional cases, however, will it be possible to discover antidotes for the poisons found in the plants. The chemical studies are made by M. R. Miller, formerly of the University of California, who is certainly entitled to great credit for the faithfulness and ingenuity which he has shown in the up-hill task assigned him.

In the course of the past year Mr. Miller has devoted a great deal of time to the isolation of the poisonous principle of the salt-bush, *Atriplex canescens,* and has separated out a number of substances

resembling saponins. These substances have the property of dissolving or digesting the red blood corpuscles. It was found that the activity of the saponins present in this plant depends largely upon the time of year when the plant was gathered. Studies of death camas by the same methods as those used with the salt-bush failed to show the presence of any form of saponin.

In connection with bulletins prepared for publication, Mr. Miller also made careful summaries of existing information concerning the active principles of the milkweeds, the death camas, and the water hemlock.

Projects 24, 26 and 27. Problems of Producing Pasturage and Silage for Feeding and Finishing Sheep.

Sunflower Silage. Eight acres of land were seeded to different types of pasture, in the autumn of 1920; they will be grazed only lightly this summer in order to bring them into good condition for 1922.

Ewes fed in part on sunflower silage as an addition to alfalfa hay, during the lambing season, made slightly better gains than on alfalfa hay alone. With the addition of a small quantity of grain they did somewhat better still. Alfalfa appeared to be essential, for, when fed grain and silage without alfalfa, there was a slight loss of weight in the ewes and less than the normal gain in the lambs.

From the fine condition of the ewes and lambs, their general appearance of thrift and activity when fed a little sunflower silage, there seemed to be good reason for hoping that it will take the place of corn silage for ewes during the lambing period. Because of its heavy yield and its excellent quality as a food, there appears to be good ground for thinking that it will be found of great and increasing value in the range cattle industry, enabling feeders in Nevada to keep their range cattle growing all winter, instead of barely maintaining weight throughout the winter months.

Preliminary chemical studies by M. R. Miller upon the acidity of sunflower silage prepared under different conditions and by different methods showed the importance of this line of work. Plans were made for a more thorough study of the matter in the coming fiscal year.

Alfalfa Pasturage for Immature Lambs. Mr. Fleming's tests with lambs which came off poor summer range too light in weight to bring a good price if shipped showed that they make very profitable gains on alfalfa pasturage. Two crops are normally cut in the vicinity of Reno; the third crop starts, but is held back by the advancing cold of September. It is generally used as pasturage for sheep. In this test the lambs were weighed on the day they went on the alfalfa stubble, and were weighed again 69 days later. The excellent gains made compare favorably with the figures from middle western lamb-feeding. The tests will be continued, costs being kept very closely, and will be published as soon as complete enough to be reliable.

Alfalfa Pasturage for "Gummers." Range ewes with teeth so worn as to be of little use, sheep around seven years old, were put on the stubble and green growth of alfalfa, after the second crop was cut. It was thought that they would be able to make good use of this pasturage, but the result showed conclusively that they could not get the fresh growth of alfalfa because of the stubble of the second crop, for

they did not have teeth enough left to graze it down. On the 69-day test they lost fifteen pounds apiece. The test will probably not be repeated.

Methods of Growing Sunflowers. This year's tests, like those of past seasons, showed that, under the conditions of soil and climate existing in western Nevada, it seems best to plow land for sunflowers in the fall. During the winter rain and snow and alternate freezing and thawing put the land into such shape that, with disking and harrowing in the spring, the seed-bed is ready. It is evidently important to get the plants up and growing early enough in the spring to take full advantage of all warm growing weather. Planted early, they grow taller and give heavier yields. If they mature early, they are protected against the blackbirds which would otherwise destroy large quantities of the seed.

In Mr. Fleming's tests the best yields were from rows 30 to 36 inches apart; 3 feet is the best distance. If planted farther apart, the rows are not close enough to make full use of the ground, and the yield falls off; if planted closer than 3 feet, the weeds are harder to control, the flower-heads of adjacent rows becomes entangled, and the crop is hard to harvest.

For the production of the best sunflower silage, Mr. Fleming has found it essential to cut the crop when the seeds of 40% or more of the plants are in the dough stage, to pack the silage well, and to use water enough to exclude air. Tests with sour milk to start the fermentation were made again this year, yielding a very fine quality of silage, somewhat better in color, odor, and general appearance than the excellent silage made without any starter.

Saving Bummer Lambs. The single set of tests made failed to develop any new method and were discontinued. Further work upon this project will be done as opportunity offers.

Feeding Concentrates to Ewes on Winter Ranges. Through an excellent opportunity for cooperation, Mr. Fleming secured data on winter range for bands totaling 10,000 ewes. Moreover, very many important facts have been secured in connection with the ages and classes of sheep which do best on winter range, band limits, and the like. Data on winter ranging of sheep have been scarce and very indefinite heretofore; and the opportunity to secure this information was more than welcome. Further facts in this same field will be secured next year and will be put in shape for publication in the near future.

Project 25. The Problem of Increasing Hay Production in the Battle Mountain Region of the Humboldt Valley, Nevada.

One of the lines of work recently attempted by the Station is indicated in the title of the project. In the vicinity of Battle Mountain the lands along the Humboldt are for the most part very nearly level; though like many other flat alluvial plains the surface is made somewhat uneven by channels worn by branches of the stream during its period of annual overflow. The stream runs in full flood during late spring and early summer, then drops sharply a little after midsummer to a point where there is usually only a scant supply of water for irrigation.

For the most part the soil is deep, the upper foot being fertile; much

of it is impregnated with alkaline salts which are readily brought to the surface by injudicious methods of irrigation. If the surface layer of soil is removed, the subsoil is found to be unproductive for a considerable time. Under these conditions deep plowing is apt to be injurious, and there are difficulties in the way of leveling of the land and the filling of old water channels.

The great fluctuation in the stream, the peculiar soil conditions, and the presence of the old water channels, have led to the adoption of methods of irrigation which seem primitive and backward; but which in reality are a rather ingenious adaptation to the actual conditions existing. These methods are sometimes condemned, but, in the absence of capital, settled titles to water, facilities for prolonged storage, they are probably about as good as could be devised. A usual practice is to build a dam across the whole channel of the stream, and back up the water and force it out over the meadow lands beyond the banks.

On the overflowed meadow lands a growth of coarse grass and sedge springs up, and the water is often held on the same fields for many weeks. When the stream recedes and the meadows begin to dry, the grass is cut, as it is then rapidly ripening and is in good condition for hay. Naturally, however, the hay from grasses such as will grow in stagnant water is somewhat coarse and is inferior to alfalfa hay.

However, with a short irrigation period, with a shallow surface soil and a relatively unproductive subsoil, with some excess of alkaline salts, a flat valley, and a river channel so near the surface of the alluvial plain that drainage is difficult—with all these and other controlling conditions, it may well be asked whether a better method of irrigation is possible under the whole set of circumstances.

Under all these conditions it will probably be best to use the land for the production of wild hay, much as it has been used, until the time comes when the settlement of all water titles along the stream and the storage of the annual flood-waters gives a basis for improvement in a decided change in conditions.

Still, without any great alteration in existing conditions and the methods growing out of them, it has seemed probable that changes might be made which would favor the production of a better grade of hay.

In the course of the past two seasons the work done on this project has brought out clearly the following facts:

(1) That with careful and patient management many soils in the Battle Mountain region are capable of producing alfalfa, barley, vegetables, and other crops of high value.

(2) That in certain parts of the valley the development of artesian water may be possible and profitable, giving an opportunity for growing high-priced crops on a small scale, and for growing an abundance of garden truck for table use on the ranches.

(3) That with care in certain localities a good stand of sweet clover may be had, and that this plant will grow under the local conditions of soil and climate better than any other grass or clover thus far tested. Sweet clover should be thoroughly tested, and every effort should be made to favor its increase.

(4) Where water can be controlled, the meadow lands should be fully and heavily flooded, as has been the practice, using as large a head

as possible and covering all the land rapidly to the desired depth. After the ground has been thoroughly soaked, the water should be turned off again and the upper layer of soil should be allowed to dry out, after which it should again be be flooded. Alternate flooding and drying will favor the growth of the better native grasses and clovers, and improve the quality of the hay.

Tests made with red clover and timothy appeared to indicate that they will scarcely survive the floodings given at each irrigation. Sweet clover survived and made good growth, averaging three feet high when cut in July.

Tests and observations will be made during the coming fiscal year along much the same lines as those followed during the past two seasons, after which it may be advisable to undertake duty-of-water studies at other points in Nevada, leaving further studies in the Battle Mountain region for the time when the settlement of water titles and the construction of facilities for the storage of flood-water shall make possible the normal development of a region which can certainly, under favorable conditions, make a great increase in fertility and productiveness.

Perhaps the most useful aspect of the work done on this project by Messrs. Bixby and Hardman is in the fact that they recognize the limiting conditions, and, without hoping for revolutionary changes in method, are studying the possibility of using practical methods of introducing such plants as sweet clover, encouraging truck patches on the ranches, and irrigating in such a way that hay of better feeding quality is produced.

Meanwhile, the benefits of the work done by successive State Engineers in the settlement of water titles are beginning to be felt. On the Humboldt, just as on most of the larger watercourses in Nevada, the first great step toward improved conditions must be the settlement of water titles along the entire stream and all its tributaries. The task of examining claims to water, mapping ranches and ditches, and making a fair allotment of water according to its beneficial use has been an enormous one, but at present it stands in a fair way to be actually completed within the near future. This will open the way for the formation of irrigation districts and the storage of flood-waters, and finally for the use of methods of irrigation and cultivation which we may hope will transform the agriculture of the entire Humboldt Valley.

Project 16. The Problem of an Unidentified Hemorrhagic Disease of Cattle.

This is a disease which seems to be fairly common throughout the region lying to the east of the Sierra Nevada Mountains. It is also prevalent in certain parts of California. Near Reno many valuable dairy animals have been lost.

In the beginning, because the symptoms resembled anthrax, many of the deaths were mistakedly attributed to this cause. Still, the anthrax germ was not found, and later, as the symptoms were also much like those of hemorrhagic septicemia, this was thought to be the disease under study until the time came when this idea had also to be discarded.

In the course of the past fiscal year a great deal of time and study devoted to this single project brought out the following facts:

(1) There appeared to be good reason at the beginning of the year to

assume that the disease might be caused by micro-organisms known as protozoa, and that the disease might really be due to coccidia. Exceedingly careful and patient investigation of this aspect of the matter by Drs. Records and Vawter showed that there are no more of these organisms present in the diseased animals than in the healthy ones and that this theory must be discarded,

(2) Later the organism which causes the disease called botulism in human beings was found in the livers of animals dead or dying from the complaint under study. For a time it appeared that *B. botulinus* might be the cause of the disease. However, it was impossible to reproduce the disease by artificial inoculation, and this theory of the cause, like the others, was finally discarded.

(3) Two common bacteria, *B. Welchii* and *B. œdematiens*, were found to be practically always present in the livers and other parts of the diseased animals. Artificial inoculation with these organisms under the right conditions promptly caused a disease very closely resembling that occurring throughout western Nevada.

Perhaps the most significant conclusion reached by Drs. Records and Vawter in connection with this project in the course of the year is that, since the disease appeared to be caused by common bacteria found in the Old World as well as in the New, there must be some peculiar condition of food, water, or climate in western Nevada which is at times especially favorable to the development of the disease.

Further work will be done on this problem in the coming fiscal year; sera and vaccines will be tried more fully, and an attempt will be made to discover the peculiar conditions under which cattle become susceptible.

Project 19. The Problem of Attacks by Horse-Flies on Cattle.

No further field work was done upon this project. All the notes and records made by J. L. Webb and R. W. Wells of the federal Bureau of Entomology were carefully arranged and summarized; and a general account of the biting-fly problem and of the conditions necessary for its solution was prepared for publication. This will appear in the course of the coming fiscal year as Experiment Station Bulletin 102, under the title "Horse-Flies and Cattle."

This will be a well-illustrated popular bulletin intended largely for local use. A little later the federal Bureau of Entomology will issue a professional paper on the same subject, in which the technical aspects of the matter will be fully discussed. Their publication will include descriptions of the insects in their various stages of growth, their habits and local distribution, the effects of their annoyance on cattle, and remedial measures which may be employed.

Project 5. The Problem of Insects Injurious to Alfalfa.

The Alfalfa Weevil. A detailed account of the activity of this insect and of the measures which are being taken by various agencies for its control is presented at this point because so many questions are received concerning this threatening pest, and this will make a convenient means of giving a general answer to these questions.

Farmers and stockmen of the State will be greatly interested in the alfalfa-weevil situation as it is now developing in fields surrounding Reno.

The weevil was first discovered at a point just outside the city limits, to the north of Reno, in June, 1920. At this time only five specimens were found; they were swept up in a beating-net by an entomologist in the employ of the federal Bureau of Entomology who had been asked by the University of Nevada to make a survey for the discovery of the weevil in western Nevada. Throughout the summer of 1920 close watch was kept by experts, but no other weevils were found in any stage of growth anywhere on the Truckee Meadows.

At the beginning of the summer of 1921 State Quarantine Officer Dr. Edward Records employed a Senior student, Mr. Noble Waite, to examine alfalfa fields in the vicinity of Reno to determine the infested area and to find out how serious the infestation had become. Waite began work in the field where larvæ were first discovered. He then examined systematically all the fields lying within a radius of five miles from the point of first discovery, later extending his survey eastward to fields lying north and east of Sparks, Nevada, and in the vicinity of the Glendale bridge. Still later, a study was made of fields lying to the south of the Truckee River, and this survey has been extended as far as the Washoe Valley. As a result, it is now known that weevils are present in all the alfalfa fields lying north of the Truckee River from a point about two miles northwest of Reno to a point about five miles to the east of the city. South of the river there is a narrow strip of alfalfa lying close to the stream which gives evidence of weevil work.

The weevil has not been found in any other fields in the valley surrounding Reno, nor has it been discovered in the Washoe Valley, nor in the vicinity of Fallon and Fernley. There is every reason to believe that Carson Valley is still free from this pest.

Many interesting things were brought out by this survey. In the first place, the weevil has not been abundant enough anywhere in the infested district to cause damage to the hay. An observer riding by the worst infested fields would be unable to detect any sign of damage. It is only when one goes into such a field and examines the alfalfa leaf by leaf that the injury becomes apparent. A close examination, however, shows many injured stems on which the leaves have been eaten away and on which the shoots have been stunted by the feeding of the green-worm stage of the weevil. The weevils themselves, small dark-brown "bill-bugs," are seldom seen in the fields, because they drop off the leaves and stems at the slightest jar and lie concealed under dead leaves on the ground. At this season it is evident that no damage will be done to the second crop of alfalfa.

Another interesting fact that stands out in an examination of the infested fields is the fact that the weevil is very thinly scattered over many square miles of territory without being destructively abundant anywhere. This indicates a slow rate of spread and increase, and makes it appear that the insect is controlled to some extent by natural conditions, and that it does not spread here so rapidly or become destructive so soon as it has in other Western States. C. E. Fleming, of the Department of Range Management in the Station, suggests that this may be due to the fact that the third crop of alfalfa is not cut but is used as pasturage for sheep in the valley surrounding Reno. Mr. Fleming suggests that a great many of the mature egg-laying beetles may be tramped to death by the sheep and that the earlier stages are

devoured in the close grazing of the fields, thus causing a slow spread and a light infestation over a large area.

On the whole, however, it seems very probable that within a few years the weevils will become abundant enough to injure the first crop of hay and seriously to set back the second crop. Spraying will then be necessary.

In June 3, 1921, a conference was held at the University, in which the federal Bureau of Entomology, the California Department of Agriculture, and the State of Nevada were represented. Forty county supervisors and county horticultural commissioners of the State of California attended the conference under the leadership of Mr. Harry Smith, Chief Entomologist of the California Department of Agriculture. The federal Bureau of Entomology was represented by Mr. Ackerman and by Mr. T. R. Chamberlain. The meeting was addressed by Mr. Chamberlain, who is connected with the federal weevil studies at Salt Lake.

The members of the party made an examination of the infested fields in order that they might become familiar with the appearance and habits of the weevil. An earnest effort will of course be made by California to prevent the introduction of the pest and to exterminate it locally in case it should appear.

There is not much probability, however, that quarantine measures against this pest will be more successful in California than they have been elsewhere in the West. For many years the States surrounding Utah have maintained an active quarantine against Utah hay and certain other horticultural products. In spite of the state quarantines the weevil has spread steadily from Utah into Colorado, Wyoming, Idaho, and Oregon, reaching Nevada last of all. The weevils have the habit of concealing themselves in unexpected places. They have been found in coal cars, in the vestibules of passenger trains, in blanket rolls and hand baggage, in packing, and in hay. They spread by flight and are distributed locally in the hauling of hay. It is almost hopeless to expect that they will be successfully excluded long from any of the Western States, and unfortunately there appears to be not the slightest hope of exterminating them once they appear in any locality. In fact, Mr. G. I. Reeves, the world's best authority on this insect, states that they are always at least ten miles beyond the limits in which they can readily be found.

At the weevil conference, Mr. Chamberlain stated that the infestation around Reno is still very light; that the weevil is evidently doing no damage as yet, and that it will probably do little damage in 1922. Spraying will probably not be necessary before 1923, or even a year later. Meanwhile agents representing spray-pump manufacturers and manufacturers of insecticides are interesting themselves in the new weevil territory and are preparing to place their products on sale in Nevada as soon as the weevil becomes sufficiently abundant.

Spraying in Utah, Colorado, and Wyoming has proven very successful. Gasoline power sprayers and sprayers of other types are used and are so effective that the total annual cost of spraying does not now exceed $1 per acre. Under favorable working conditions it can be kept

below this figure. This means only a very moderate increase in the cost of raising alfalfa hay. The State of Utah is raising just as much alfalfa of just as good a quality as before the first weevil outbreak.

On the whole, there is little reason for the general feeling of alarm which prevails in California over Nevada's incipient weevil outbreak. When the weevil does become destructive in Nevada the farmers will spray their fields once each year and will readily keep the pest under control.

The Agricultural Extension Service of the University, under the direction of Mr. Cecil W. Creel, is planning a campaign of instruction in spraying methods. Demonstrations will be made in which the most suitable pumps and the most effective insecticides will be employed. The work will be organized under the local branches of the Farm Bureau and will be a community effort.

Meanwhile the Nevada Agricultural Experiment Station is active in the introduction of parasites which have proven effective in greatly reducing the number of weevils in Utah. These parasites are tiny four-winged insects resembling minute wasps. They sting the green-worm stage of the weevil, laying an egg in each worm. The egg develops into a maggot, living within the body of the worm, devouring its tissues, and finally destroying it. The worm grows almost to maturity before it is killed by the maggot, but in certain fields near Salt Lake City the parasites are now destroying fully 90% of the weevil larvæ. This successful parasite is the sole survivor of nineteen different species which have been introduced by the federal Bureau of Entomology. Under the direction of Dr. L. O. Howard, Chief of that Bureau, they have been brought in since 1907 from France and Italy. Nearly all have perished because climatic conditions in Utah differ so greatly from those in the Mediterranean region. There are, however, several other of these tiny wasp-like creatures, found in northern Italy and Switzerland and in parts of France, which can probably be introduced successfully into western America; and the federal Bureau of Entomology is now sending Mr. Chamberlain to Europe to secure colonies of these beneficial forms. There is good reason to hope that they will be as effective as the single species which has taken hold in Utah.

In June the Experiment Station secured from Salt Lake a colony of the successful parasites through the kindness of Mr. G. I. Reeves of the Bureau. These were reared on the University Campus, were fed, and were then released in the most heavily infested field near the University. They immediately attacked the weevil larvæ, and there is reason to hope that the introduction will be successful. The Station hopes to make further introductions on a larger scale in 1922, and for several years thereafter. If the parasites do as well in western Nevada as they have in the Salt Lake Valley, they should retard the spread of the weevil and help to keep the numbers down to the point where a single spraying will be wholly effective or even, in the long run, to the point where spraying may become unnecessary.

On the whole, the University's studies of the weevil outbreak this summer indicate that the insect has been present in small numbers for

a considerable period; that its spread has been retarded by natural conditions; that it is not yet destructive or even injurious, and that it will not become so for at least a year or two more. This will give ample time for the organization of spraying campaigns, and there appears to be no doubt that the pest will be controlled at a cost which will be only a slight addition to the present cost of raising alfalfa.

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Annual Report of the Board of Control for the Fiscal Year Ending June 30, 1922

PUBLISHED BY THE UNIVERSITY OF NEVADA
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CARSON CITY, NEVADA
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1922

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NEVADA AGRICULTURAL EXPERIMENT STATION

I. FINANCIAL STATEMENT

C. H. Gorman

Nevada Agricultural Experiment Station

IN ACCOUNT WITH

The United States Appropriations, 1921–1922

Items		Hatch Fund	Adams Fund
Debit			
To balance from appropriations for 1920–1921		$0.00	$0.00
Receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1922, under Acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund)		15,000.00	15,000.00
Credit	Abstract		
By salaries	1	$9,471.65	$8,770.20
By labor	2	2,816.82	2,570.27
By publications	3	105.91	0.00
By postage and stationery	4	277.53	25.70
By freight and express	5	37.58	135.93
By heat, light, water and power	6	98.42	298.85
By chemicals and laboratory supplies	7	0.00	308.95
By seeds, plants and sundry supplies	8	225.48	144.35
By fertilizers	9	0.00	0.00
By feeding-stuffs	10	67.82	572.40
By library	11	32.24	28.45
By tools, machinery and appliances	12	129.10	28.10
By furniture and fixtures	13	43.25	22.10
By scientific apparatus and specimens	14	4.50	283.65
By live stock	15	542.82	1,493.80
By traveling expenses	16	617.54	317.25
By contingent expenses	17	0.00	0.00
By buildings and land	18	529.34	0.00
Balance		0.00	0.00
Total		$15,000.00	$15,000.00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Nevada Agricultural Experiment Station for the fiscal year ended June 30, 1922; that we have found the same well kept and classified as above; that the balance brought forward from the preceding year was $0 on the Hatch Fund and $0 on the Adams Fund; that the receipts for the year from the Treasurer of the United States were $15,000 under the Act of Congress of March 2, 1887, and $15,000 under the Act of Congress of March 16, 1906, and the corresponding disbursements $15,000 and $15,000; for all of which proper vouchers are on file and have been by us examined and found correct, leaving balances of $0 and $0.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said Acts, respectively.

(Signed) D. J. SULLIVAN,
State Auditor.

Attest: C. H. Gorman, *Custodian.*

II. LIST OF PROJECTS

HATCH FUND

IRRIGATION:

Project 25. *Methods of Increasing Hay Production in the Humboldt Valley, Nevada.* 1919–1922. Project Leader, F. L. Bixby, assisted by Mr. Geo. Hardman.

Project 29. *Duty of Water Studies in Southern Nevada.* 1922–Continuous. Project Leader, F. L. Bixby, assisted by Mr. Geo. Hardman.

ENTOMOLOGY:

Project 5. *Insects Injurious to Alfalfa.* 1916–Continuous. Project Leader, S. B. Doten.

RANGE MANAGEMENT:

Project 23. *Revegetation of Depleted Ranges.* 1916–Continuous. Project Leader, C. E. Fleming.

Project 24—*Lamb Protection: Methods of Producing More and Better Lambs in Nevada Range Flocks.* 1919–Continuous. Project Leader, C. E. Fleming.

Project 26. *Feeding and Finishing Range Ewes and Lambs.* 1920–Continuous. Project Leader, C. E. Fleming.

Project 27. *Pasturage and Silage Production for Sheep.* 1920–Continuous. Project Leader, C. E. Fleming.

ADAMS FUND

VETERINARY SCIENCE:

Project 16. *Hemorrhagic Disease in Cattle.* 1914–Continuous. Project Leader, Dr. Edward Records, assisted by Dr. L. R. Vawter.

RANGE MANAGEMENT:

Project 20. *White Sage Studies.* 1916–Continuous. Project Leader, C. E. Fleming.

Project 22. *Poisonous Range Plants.* 1916–Continuous. Project Leader, C. E. Fleming, Assisted by M. R. Miller and Drs. Records and Vawter.

PUBLICATIONS OF THE NEVADA AGRICULTURAL EXPERIMENT STATION, FISCAL YEAR 1921-1922

Annual Report of the Board of Control for the Fiscal year Ending June 30, 1921. By S. B. Doten.

This is a pamphlet of twenty pages with two photographic illustrations. It includes a financial statement summarizing the expenditures under the federal Hatch and Adams funds and gives a list of the active projects of the Station, with the report of the Director and an account of progress made during the year in the experimental projects under study.

Horse-Flies and Cattle. Bulletin 102, Nevada Agricultural Experiment Station. By S. B. Doten.

This is a pamphlet of thirteen pages with eight photographic illustrations, giving in popular form an account of the study of annoyance and injury to cattle by horse-flies in the Antelope Valley region of Nevada and California. The study was a joint project of the Nevada Station and the Federal Bureau of Entomology. The field work was done by Messrs. Webb and Wells of the Bureau with the assistance of students from the University and with the cooperation of the writer.

Field and Laboratory Study of Redwater in Cattle in Nevada, 1921. By L. R. Vawter and S. Lockett. "Veterinary Practitioners Week," California Agricultural Experiment Station, University Farm, Davis, California, January 2 to 6, 1922. Proceedings Published by California State Veterinary Medical Association, pp. 47 to 56; Discussion, pp. 57 to 65.

The published article gives in technical form for the use of the veterinary practitioners of the Pacific Coast a thorough statement of the work done upon this project in the Nevada Station. A history of the disease in Nevada is given, with an account of its occurrence elsewhere, and a statement of its local economic importance. To this is added a review of the published literature, and a detailed account of experimental studies upon its cause and control. The Discussion gives additional data upon the occurrence of this disease in California.

Death Camas. By S. B. Doten. (An account of Feeding Experiments carried on at the University of Nevada by Prof. C. E. Fleming and Associates.) American Sheep Breeder and Wool Grower, Vol. XLII, No. 2, Chicago, February, 1922.

This article is an illustrated popular account of the work of the Nevada Experiment Station with Death Camas. A description is given of the appearance of the plant and its attractiveness to sheep and other animals. The conditions under which poisoning occurs are detailed and an account is given of methods of avoiding losses.

The Poison Parsnip or Water Hemlock. By S. B. Doten. (An account of the Results of Feeding Experiments with Range Animals Carried on at the University of Nevada by Prof. C. E. Fleming and Associates.) American Sheep Breeder and Wool Grower, Vol. XLII, No. 3, Chicago, March, 1922.

This popular statement of the experimental work of the Nevada Station with Poison Parsnip gives a description and photographs of the plant, tells how to recognize it in the field, describes its habits of growth and spread and gives a detailed account of the results of feed-

ing experiments. Methods of avoiding and preventing losses are described.

Squirrel-Tail Grass in Hay Fatal to Ewes and Their Lambs. By S. B. Doten. (An account of Studies of the Common Grass Known as "Squirrel-Tail," "Fox-Tail," or "Tickle Grass," made at the University of Nevada by Prof. C. E. Fleming, N. F. Peterson, and associates.) American Sheep Breeder and Wool Grower, Vol. XLII, No. 5, Chicago, May, 1922.

This is a popular account of injuries to sheep and lambs caused by the dried seed-heads of this grass when it is fed to sheep and lambs in hay.

III. REPORT OF THE DIRECTOR

A New Period in Nevada Agriculture.

There are many indications of the beginning of a new period of agricultural development in Nevada. It now appears that ranch and range will be in time partially replaced by a type of agriculture in which considerable areas will be devoted to special crops and diversified farming. Still, this change may be not so much a replacement as a new and further development.

The long parallel mountain ranges which rib the whole State from north to south will always offer range pasturage for millions of sheep and cattle; and for an indefinite period most of the farm lands of Nevada will be used for raising hay for the winter feeding of live stock. The great sheep and cattle industry based on a combination of summer and winter range with winter feeding gives opportunity for the best use that can be made of most of the land within the limits of the State.

In recent years, in many of the other western States the open range has been broken up into farm lands, fenced, planted, and thus put to a far more productive use than that of merely furnishing a rather scant supply of grass and herbage for a few range animals. In Nevada, however, so much of the range country is literally mountain range, too steep and too high for farming that we can expect little reduction in the area now devoted to sheep and cattle grazing. Apparently, fully as much hay will be needed in the future as in the past for the winter feeding of live stock.

At present the waters of the streams are used as fully in irrigation as their low-water stages will permit; still, there is a good prospect that the economical use and storage of water and the development of further supplies of underground water will permit a considerable increase in the total area under irrigation.

For years past it has seemed that in western Nevada at least there is an excellent local market for many products which might well be raised on farms near at hand instead of being raised in other States and then shipped to Nevada from California and Utah.

Eggs and poultry, ham and bacon, condensed milk, vegetables and certain fruits, canned goods of several kinds, all might be produced in western Nevada to supply the local markets and for shipment to adjacent parts of California. It is evident that it may be possible to produce honey, beet sugar, cantaloupes, and certain other products in quantities sufficient to supply markets at a considerable distance, even on the Atlantic seaboard.

For years past the Agricultural College has emphasized the fact that good local opportunities for diversified farming and special crops were being overlooked by farmers in western Nevada. Well-informed leaders among Nevada business and professional men have kept this subject alive; in this connection it is only fair to mention Mr. J. M. Fulton of Reno, Nevada, who has for years constantly taken every means of calling attention to the undeveloped possibilities of the rich farm lands of western Nevada located close to transcontinental railroads which give the best of marketing facilities. Mr. Fulton has constantly urged that at least the local markets in the cities of western Nevada should be

kept supplied with home-grown vegetables, fruits, poultry and dairy products.

The Agricultural College, the Agricultural Extension Service, and the leaders of the Farm Bureau, have given force to the movement until it is now developing in a way which promises a more profitable type of farming, increased farm population, heavier yields and higher property valuations.

Special Crops and New Problems.

Each special crop raised will bring in new problems of planting, cultivation, and irrigation; new problems in labor and marketing, in soils, and in plant diseases and insect pests. For example, sugar-beet growing will bring up in any locality a number of problems which are not now especially acute. Each farmer growing the crop must learn how to handle it; experience with grain and alfalfa under irrigation does not necessarily fit a man to grow sugar-beets. He must learn how to plant and cultivate and care for the new crop. A labor supply not now at hand must be provided, perhaps at the risk of introducing a new labor and race problem not now in existence. Special machinery must be purchased, and the effect of hauling a heavy tonnage of beets over local roads must be considered.

The fact of the matter is that with each change in existing practice and for each special crop that may be raised, a new set of problems will inevitably be introduced; and for each the subject of plant diseases and insect pests will assume new importance.

Nevertheless, on the whole, there seems to be good reason for assuming that the development of the movement away from ranch and range toward special crops and diversified farming will be continuous and profitable within the natural limits of the economic situation in Nevada. A high standard of farming will be required, with cultivation, weeding, spraying, the rotation of crops and generally good farm management.

The New Period and the Water Problem.

Very evidently, however, the central problem will still be the water problem. For special crops water must be provided throughout the growing season. The limits of the new development will be determined by the amount of water available for irrigation in late summer and early autumn. In general, then, the most important condition favorable to the new development is and will be the regulation of the flow of the running streams on which irrigation depends, through the storage of flood waters. This is an engineering problem; but it is also a problem in finance. A storage project may be sound from an engineering standpoint and even brilliantly successful, yet financially it will be a failure unless crops raised under it can ultimately pay the bill. Any stream regulation and water storage financed by private capital must pay for itself. In the long run the first cost and the subsequent maintenance of dams and canals, the yearly expense of their conduct and the interest on invested capital must all be met from the sale of products raised upon the lands served by them.

The engineering aspects of further farm development in Nevada belong rather less to the College and Station than to the office of the State Engineer. The extremely important work of stream measurement, and the settlement of titles to water on all the principal streams of the State have made steady and rapid progress under successive

State Engineers. In fact, the work has now progressed to a point where it will soon be possible to say how much water still remains unappropriated in the water courses of the State and to determine the extent to which it will be profitable to build dams and canals for the storage and distribution of flood waters which now run to waste.

On the whole the extent and the success of the new movement toward diversified farming and special crops will depend upon the location of the land, the marketing facilities, the local climate and soil, and the quantity of water which is available late in the growing season.

The coming development in more specialized agriculture will keep the Extension Service busy in providing local leadership and giving information upon the special problems as they arise. It will react upon the Experiment Station by bringing out a demand for information on topics not fully investigated elsewhere, with local applications of methods of control worked out in other States for conditions not completely similar to our own. Moreover, the Station men will be called upon to an increasing extent for assistance in obtaining information on special topics for the use of members of the Extension Service.

Sources of Support of the Nevada Station.

It is evident that if the Experiment Station is to assist the progress of the new movement in Nevada agriculture and to meet the growing demands made upon it, further funds must be provided for the work; unless lines of experimental work now in progress are sacrificed.

At present the Station is supported almost wholly by federal funds, the Hatch Fund and the Adams Fund, each of which amounts to $15,000, making an annual total of $30,000. A sum of about $1,000 has been expended yearly from state public service funds; but these expenditures have intentionally been kept as low as possible. Additional State aid might well have been asked for and would have been granted; but it is evident that the people of Nevada must carry a heavy burden of taxation in order to maintain roads over an immense and thinly-populated area, to provide for education, and to pay the necessary expenses of county, municipal and state government. Under these conditions it has seemed best that the Experiment Station should keep its expenditures within the limits of its federal funds and that except in emergency the State should not be asked to bear the expense of experimental studies, but should be encouraged to devote all available university funds to class-room teaching and to extension work in agriculture.

Economies in the Handling of the Federal Funds.

In the expenditure of the federal funds economy has been practiced. In addition to the accounts kept by the University Comptroller a special set of ledger accounts has been kept in the Director's office, showing the cost of each project or group of projects in the Station. A careful account has been kept of the station sales fund. Pelts and wool, lambs, superfluous experimental animals, implements and apparatus not immediately needed have been sold. The sales fund has been of increasing importance in providing money for repairs and fencing on the Experiment Station farm and for the general upkeep of implements, and implements. The number of lines of experimental work and study has been strictly limited; although it has been possible so to group related projects that many subjects have actually been investi-

gated in recent years. By planning expenditures long in advance and by watching the funds closely it has been possible to pay reasonably good salaries to Station men, and to provide ample labor and facilities for the lines of work actually in progress.

Through the cooperation of the Governor and the State Printer the bulletins of the Station have been printed in excellent form on a good grade of paper; drawings and photographs have been freely used in these publications, and even a few color plates have been issued.

Economies have also resulted from combining several lines of work in one division of the Station and from making the divisions themselves rather vague and elastic. For example, the Department of Range Management is conducting experiments with certain field and pasture crops which are used as supplements to the range feed. The same department is growing sunflower and corn silage and is testing methods of seeding, cultivation, irrigation, and harvesting of the Russian sunflower. In the winter, feeding experiments are conducted. Normally these various lines of work might well be assigned to Departments of Agronomy and Animal Husbandry. The station secretary is also bookkeeper and librarian; in addition to these duties she makes line-drawings of plants and other subjects, retouches photographs, and paints water colors of poisonous plants.

The chemist, the veterinarian and the chief in range management combine in the study of poisonous plants; the Director is also entomologist, photographer, and bulletin editor. No station project is considered to be the exclusive property of a single department; lines between divisions are indefinite; each man is at liberty, if qualified, to employ the methods of any science needed for the solution of a special problem.

Need and Prospect of Additional Federal Funds.

On the whole, in spite of all economies, it is evident that the Nevada Station would be of far greater local service if it had more funds at its disposal. It is not advisable, probably scarcely fair, to ask for additional funds from the State. The provision of increased support from federal sources would make it possible to do more extensive and effective work on projects already established. Studies of range problems could very profitably be greatly extended; it seems certain that these studies would be of service to the entire West. Likewise a very considerable amount of money might be spent upon the study of the underground waters of Nevada, their development, and the study of their use on crops; and further considerable sums might be expended on studies of the use and duty of water from running streams fed by melting snows. There are many problems to be solved in connection with crops now grown; and there will annually be an increase in important problems of soil and cultivation, fertilization, insect pests and plant diseases with the progress of the movement toward special crops and diversified farming.

Fortunately there is some prospect that additional federal support may be provided through the passage of the Purnell bill which promises generous additions to the funds now at hand. The passage of the bill will be of great service to experimental work in Nevada agriculture. One line of work in particular will be greatly benefited, the study of the economical use of water upon crops. The fact is that this will be for many years to come the central problem of Nevada agriculture.

We have far more land, good rich soil, than will ever be cultivated: there is little hope for dry farming in Nevada; the great question is how to make a limited supply of water go just as far as possible in profitable crop production. All the present funds of the Station could well be expended upon the systematic study of this one problem alone in its various aspects in different parts of Nevada. Yet only the provision of additional federal funds will make it possible to study this problem continuously and adequately.

Relation of the Station to the University as a Whole.

The relationships of the Station men with the remainder of the University organization have been harmonious and mutually beneficial. Members of the Station staff have not been asked to do any teaching except as it might readily be done without in any way impairing the project work of the Station. The Director has been given the fullest liberty in hiring men or in terminating their employment. In the winter, when for several months work with field crops and irrigation could not be conducted it has proven both convenient and desirable that Station men should devote part of their time to teaching.

Professorial Rank of Experiment Station Staff.

In the course of the fiscal year the Nevada Station was officially recognized by the President and Regents of the University as a research division of the institution and the members of the Station staff were assigned professorial rank corresponding to their responsibilities in the Station and to their training and length of service. Upon recommendation of President Walter E. Clark the members of the Station staff have been listed as research members of the University faculty with the following titles:

Samuel Bradford Doten, M.A., Professor of Agricultural Research.

Edward Records, V.M.D., Research Professor of Veterinary Science.

Charles Elliott Fleming, B.S.A., Research Professor of Range Management.

Meredith Raines Miller, B.S., Associate Research Professor of Agricultural Chemistry.

George Hardman, M.S., Assistant Research Professor of Irrigation.

Lyman R. Vawter, D.V.M., Assistant Research Professor of Veterinary Science.

Relations with the United States Department of Agriculture.

Relationships with the bureaus of the United States Department of Agriculture have been maintained as heretofore. The studies of biting flies of cattle carried on jointly with the Bureau of Entomology from 1916 to 1919 were completed and terminated. The studies in irrigation heretofore carried on along the Humboldt River in cooperation with the Bureau of Public Roads were discontinued; and for them was substituted a study of irrigation from artesian wells and by water pumped from underground sources near Las Vegas. Plans were also made for the beginning of soil surveying in southern Nevada in cooperation with the Federal Bureau of Soils.

On the whole, the Station is under many obligations to the bureaus of the United States Department of Agriculture and is glad to welcome representatives of any of its divisions who wish to study special prob-

lems in Nevada. The courtesies of the situation have been scrupulously observed by all department workers representing the federal bureaus; and the relationship has been very helpful to this Station.

The Experiment Station Library.

Owing to the great increase in the number of students in attendance at the University it became necessary to remove the Station library and mailing room from the space occupied for several years past in the library building of the University and to house the stacks again in the Station building. Portions of the offices of the Director and the Department of Range Management were set aside for this purpose. A small mailing room was fitted up with shelving and facilities which provide for the prompt mailing of bulletins. Stacks and shelving for books and bound volumes of bulletins and reports were so placed that the Station library has become more accessible and useful to workers than it has been in the past.

The Experiment Station Library

At the same time it became clear that some restrictions must be placed upon the withdrawal and use of Station bulletins by students in the Agricultural College. For several years they have been permitted to withdraw bulletins and reports at will through the usual library system of the University. This privilege, however, has resulted in the loss of most important bulletins from the files of recent unbound issues. The losses from this and similar sources have been so heavy and the material missing is so important that it now seems probable that the Station library will have to be regarded hereafter more strictly as the working library of the Station staff, and that withdrawals of books and pamphlets will have to be restricted and much more carefully guarded.

In all probability a partial solution of the problem will be found by permitting students in the Agricultural College to use the Station

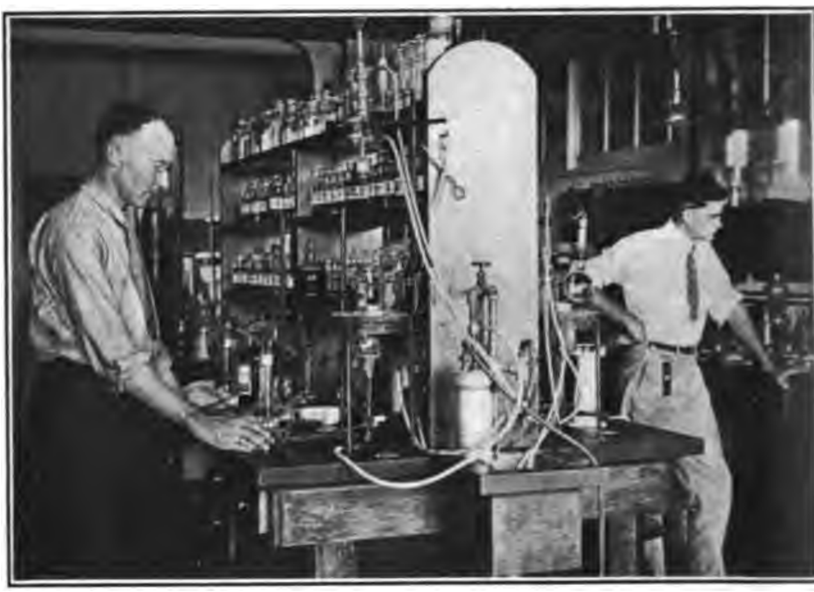
library as a reading room for topical references without any actual withdrawals of bulletins and reports.

In the coming fiscal year a most active effort will be made to replace missing numbers and to bind the series up to date as far as this may be possible.

It is hoped that the necessary restriction in the use of the library will lead the College of Agriculture to build up in their reading room an indexed collection of bulletins and reports arranged in pamphlet cases by topics for ready reference by students. The divisions of the college should now begin to forecast their topical assignments for each semester and to provide ample material in the form of bulletins and reports arranged for easy reference, thus economizing the time and effort of the students and of the Station librarian.

The Chemical Laboratory.

The recent increase in the student body of the University caused the



The New Chemical Laboratory

Chemistry Building to become so overcrowded that it was necessary to provide additional laboratory space. The chemical laboratory of the Station occupied space of the utmost importance in the building; and it was evidently a necessity that the rooms should be given up. In this crisis Dean Robert Stewart of the College of Agriculture offered the Station the use of ground-floor rooms in the Agriculture Building, thus furnishing a happy solution of the problem. Two large rooms were provided; and the floor space now occupied is but little less than that in the old laboratory.

The removal made it possible to bring about many improvements in the arrangement of facilities and apparatus. Very careful study was given to the matter by the Station Chemist, M. R. Miller, who made a

most effective and ingenious arrangement of apparatus, and instruments in the space assigned.

It was found to be impossible to remove the chemical desks and lockers from the old location to the new. They were built into place and could not be knocked down without destroying them. For this reason it was necessary to construct an entirely new equipment of benches, desks and lockers, each unit being provided with water, gas, electricity and sewer connections. The floors of the new rooms are of cement painted; none of the equipment was attached to the floors except through the necessary wiring and piping. All furniture was constructed of the best material in accordance with standard plans. This will make it possible, if necessary at a later date, to remove the whole equipment to still another location at minimum cost.

The equipment and facilities now in place would readily provide for a considerable increase in the working staff of the laboratory without overcrowding, a matter which will be of considerable importance when additional federal funds become available.

CONDENSED ACCOUNT OF WORK DONE UPON STATION PROJECTS DURING THE FISCAL YEAR

Project 25. The Problem of Increasing Hay Production in the Humboldt River Valley, Nevada. F. L. Bixby and Geo. Hardman.

According to the original plan this problem was to be studied on ranches near Battle Mountain, Nevada, from 1919 to 1924. Since the results were the same for each year and because they pointed to the same general conclusions, it did not seem advisable to continue the work at this point any longer; and in view of the demand for the study of irrigation from artesian wells and by pumping from underground sources in the Las Vegas Valley of southern Nevada it seemed advisable to discontinue work on Project 25 and to prepare the results for publication.

The work of the past fiscal year, however, was of importance in confirming the conclusions reached earlier and in giving a good deal of very interesting information concerning the possibilities of the region.

When the project was first outlined it seemed probable that changes in irrigation practice could be made which would result in a marked increase in the productiveness of these important hay lands. There seemed to be a good prospect also that it would be possible to substitute cultivated grasses and clovers and even some alfalfa for at least a part of the wild grass which now makes the hay of the Battle Mountain region. The work of the past season on this project taken in connection with that of previous seasons showed most clearly that while this is possible a permanent improvement depends directly upon conditions outside the control of the ranchers along that part of the Humboldt. Improvement on a large scale is out of the question as things now stand, and nothing but the settlement of titles to water along the entire Humboldt and its tributaries, together with the storage of flood waters will make any great progress possible.

Another thing was brought out clearly; and that is the fact that the methods of diversion of water and irrigation now practiced by the Battle Mountain ranchers seems to be on the whole better adapted to existing conditions than any methods which can be substituted for

them. Only water storage and a total change in conditions will make better methods possible. To build brush dams across the shifting channels of the stream and back up the water out over the flats to irrigate them and produce wild grass hay is about as good a method as could be devised for making some use of lands which would otherwise yield little or nothing.

The study of this problem showed clearly, however, that in years when the flood of the stream is not too high it is a good plan to flood the hay lands for a time and then to release the water, let the soil partially dry out, and flood again. This intermittent irrigation produces more and better hay, but the system can be used only when the water is low enough to be under control.

Another thing brought out by this investigation is the fact that an attempt should be made to increase and spread the common white-flowering sweet clover which grows better in the Battle Mountain region than any other of the clovers and grasses which were tested. Sweet clover is somewhat resistant to alkali and is not so readily drowned out by the flood-waters as were several other plants and grasses under trial.

The hope of the Battle Mountain region of the Humboldt River valley lies in the storage of the floods and the regulation of stream flow. Meanwhile, under existing conditions the lands are on the whole being put to a good and intelligent use which can be improved by intermittent irrigation in favorable years, by the introduction of sweet clover, and by the development of alfalfa fields in the most favorable locations. Both alfalfa and sweet clover have an exceedingly beneficial effect on the soil where they can be grown.

Project 29. The Problem of Irrigation with Water from Underground Sources in the Las Vegas Valley. F. L. Bixby and Geo. Hardman.

There is good reason to hope that the extreme southern portion of Nevada will increase greatly in prosperity and in population in the near future. The proposed construction of the Boulder Canyon dam on the Colorado River promises to be of great indirect benefit to the Las Vegas region; and the development of additional supplies of water from underground sources will be greatly aided by the cheap electric power for pumping which will follow the construction of the dam. The climate of southern Nevada is well adapted to the production of figs, choice grapes, peaches, apricots, cotton, and a variety of other products; experiments with water and crops conducted there are of unusual interest and importance.

It is evident that two lines of work are involved: (1) the study of the engineering aspects of water development, including methods and costs of boring wells, costs of pumping, and profitable lifts together with data upon the nature and extent of the source of supply; (2) the study of methods of irrigation, including ditch and canal construction, and the economical use of water in crop production.

Studies in irrigation will form a good foundation for later studies in agronomy and horticulture in the same region. If in the near future additional federal funds shall become available, other important experimental work will be done in the Las Vegas region.

Project 5. The Problem of Insects Injurious to Alfalfa in Nevada. S. B. Doten.

The alfalfa weevil has been studied under this project in the past fiscal year. The spread of this pest has seemed slow in the portion infested. It now covers most of the valley north of the Truckee River and is spreading gradually to the south. On the whole the infestation has not been severe at any point and thus far little damage to hay has resulted. There is every reason to expect that within two or three years many of the fields now lightly infested will be so heavily stocked with the weevil that the first crop of alfalfa will be severely injured and the second crop will be so slow in starting that a heavy loss will result.

Meanwhile the Extension Service is watching the situation very closely and is preparing to conduct demonstrations of methods of spraying with arsenicals for the control of this pest.

The Experiment Station has hoped to somewhat retard the spread of the alfalfa weevil and to assist in holding it in check by the introduction of natural enemies and parasites of the weevil. To this end, through the kind cooperation of Dr. L. O. Howard of the Bureau of Entomology and Mr. G. I. Reeves, parasitized weevil larvæ were obtained from Salt Lake. From these weevil larvæ considerable numbers of the parasites were obtained and were released early in the summer of 1921 in a field of alfalfa near Reno which was most heavily infested with the weevils. It is hoped that this colony may form a nucleus from which the parasites will spread over the whole infested region.

Project 23. The Problem of Revegetating Depleted Sheep and Cattle Ranges. Range Flocks. C. E. Fleming.

Funds have not been available during the past fiscal year for active field work in the study of this problem. The money which was at hand has been spent upon other problems which were of more immediate importance to stockmen. The fact is that upon the open, unfenced range, the government domain, there is no chance whatever of improving present conditions and that these conditions may be expected to become steadily worse, rather than better. Until the Federal Government sees fit either to create grazing reserves on its western public lands which are unfit for other use, and to control grazing upon them in the interest of restoring these ranges, or until it shall make arrangements by which these lands can legally come into private control or State control in large areas, little or nothing can be done toward increasing their carrying capacity or toward protecting them against further injury.

Project 24. The Problem of Producing More and Better Lambs in Nevada Range Flocks. C. E. Fleming.

The Use of Better Bucks. Tests with bucks of higher quality than those commonly used in Nevada showed that lambs make faster gains in weight on the same feed, show better form, and give more and better wool, where the better bucks are employed.

Lambing Under Shelter. No additional facts and figures on this subject were secured in this fiscal year.

Feeding Ewes Which Lamb Under Shelter. This experiment is a series of tests of various feeds to determine the effect of food upon the

milk supply of the ewe and upon the subsequent growth of the lambs. A number of feeds were tested; but the final effects upon the weight of the lambs cannot be determined until the autumn of 1922.

Project 26. The Problem of Feeding and Finishing Range Ewes and Lambs Prior to Shipment to Market in the Autumn. C. E. Fleming.

Tests showed that it is unprofitable to attempt to do anything more with discarded range ewes. Their mouths are too poor to permit them to make use of available feeds, and it is improbable that this experiment will be continued. Tests of various feeds for finishing lambs have given very interesting results. The tests with alfalfa pasturage on fields from which two crops had been cut showed the excellent gains that can readily be made on this pasturage and indicated that where the climate is too cold for a third crop and where soil conditions will permit a most excellent use is made of the last growth of the fields in this way. Other feeds were also tested and the interesting results obtained showed that immature range lambs can be profitably finished for the market in the autumn under western Nevada conditions. These tests are of such importance and the figures which are being obtained are so interesting that the feeding trials will now be continued for several additional seasons.

Project 27. The Problem of Producing Pasturage and Silage for Sheep Under Western Nevada Conditions. C. E. Fleming.

Because a considerable number of sheep must be carried throughout the year on the Experiment Station farm for the experiments outlined above and for studies with poisonous plants, it has been necessary to provide good pastures for them throughout the summer. In this connection some tests were made to find out what sort of pasturage would be best for this purpose and to discover how many sheep might be carried on the Station farm without injuring well-established pastures.

Early in the summer of 1922 the pastures which had been planted in previous seasons were fully established and the test was begun. The results were somewhat astonishing. In the first place, dutch clover showed its ability to run out practically all the other grasses and clovers tested under pasture conditions. The grazed areas are now composed almost wholly of this clover with just a little blue grass. The clover has rooted well and has made a fine stand. Sheep have done so well on it that it now appears to be possible to carry as high as eighteen head or even more per acre. The pastures have been divided into smaller units and the sheep were turned into one at a time. A great deal of care was used in keeping the sheep off the pastures just after they were irrigated. This prevented the puddling of the soil and kept the clover growing vigorously. After each section of pasturage was grazed down the sheep were moved to another section which had grown up meanwhile, and they were not put back on the first section until there was again a good stand of clover.

Production of Sunflower Silage. The work of this fiscal year made it evident that it is not necessary to use sour milk as a starter of fermentation in sunflower silage. A most excellent grade of sunflower silage has been produced now for two succeeding years without the use of

milk. Where the milk was used, a silage just a little lighter in color and perhaps of slightly more attractive odor was produced; but on the whole there was no difference of sufficient importance to warrant the use of the milk. The tests have shown conclusively that sunflower silage of the highest quality can readily be made under western Nevada conditions.

Various methods of planting, cultivating, and irrigating the sunflowers have been tested for several seasons past, and a statement of the most successful method will soon be published for the use of Nevada farmers and stockmen.

Project 16. The Problem of an Unidentified Hemorrhagic Disease in Cattle. Drs. Edward Records and L. R. Vawter.

The close resemblance of this disease to anthrax and to hemorrhagic septicemia led to confusion with those diseases in the earlier days of veterinary studies in Nevada. It was shown to be distinct; and for several years past attempts have been made with consistent thoroughness to find its cause and to discover some means of control.

The work of the past fiscal year did not fully clear up the question of the cause of this disease. Tests showed that the disease may be caused by a minute organism known as *B. welchii,* probably in combination with other bacteria, but the causes which make the animal susceptible to the attack of these organisms have not been fully discovered.

The work of the past year taken in connection with that of all previous years, showed that the disease can be cured in its early stages by serum treatment, but thus far no specific serum has been devised and the good results obtained were probably due to the effect of the horse serum administered. Another thing that stood out in the results of the experimental work of this year was the fact that no treatment is of any use after the disease has made progress to the stage of bloody urine and feces. In the earlier stages the disease is distinctly curable, and the percentage of recoveries in treated cases is decidedly high, but in the later stages so much damage has already been done that the animal is past recovery.

Prevention of the disease by vaccination has been tested thoroughly and on a large scale, but thus far the results of thousands of trials have been disappointing. The work of the past year, however, gave some ground for hoping for more successful experimental work along this line in the near future.

Project 20. The Problem of the White Sage Ranges. C. E. Fleming.

Like other studies of improvement of depleted ranges this project has shown clearly that progress is out of the question under present range conditions. The crying need of the sheep and cattle in Nevada is the regulation of its range lands by the Federal Government. Any sort of control is better than no control, and it is to be hoped that in the near future the Federal Government will recognize the importance of the Nevada range country and will either administer it as the forest reserves are now administered or make it possible for corporations to acquire legal control over areas or else turn over the grazing lands of Nevada to the State to be administered in the interest of their permanent use without abuse, and in the interest of increased carrying capacity per acre.

Project 22. The Problem of the Poisonous Range Plants. C. E. Fleming, M. R. Miller, Drs. Records and Vawter.

In the past fiscal year as in previous ones it has been very clearly evident that in Nevada poisonous plants cause heavier losses of livestock than all the recognized animal diseases. Stockmen show the keenest interest in the problem of the poisonous plants of the sheep and cattle ranges.

This year witnessed the completion of feeding tests with the small larkspur. These tests were of the same character as the others which have been made in past years. The animals which were experimented with were full-grown sheep and cattle from the ranges. All the results of feeding experiments with the small larkspur will be published in the coming fiscal year.

Tests with a common rabbit brush were also completed and prepared for publication; and a large number of feeding tests were made with other important poisonous plants.

On the other hand, several plants which have been suspected of being poisonous were tried out very carefully and the results showed conclusively that they are not at all dangerous.

An active and most consistent effort has been made to separate out the poisonous principles of the plants under study and to determine their chemical nature. Much progress has been made along this line: but the work of the past year was somewhat hampered by the removal of the Station's chemical laboratory to a new location. However, the greater efficiency of the present arrangement of apparatus and instruments in the new laboratory will in the long run prove beneficial to these studies.

Another interesting development of the poisonous plant studies has been the fact that the working out of the dangerous and fatal doses has given a good opportunity for the experimental study of methods of cure of animals which have become poisoned on the range. In a general way it may be said that there is seldom any opportunity for the treatment of the poisoned animals. However, such opportunities do occur and it is well to know whether anything can be done for an animal which shows symptoms of plant poisoning. In the past year a method of treating cattle poisoned by larkspur was tested with success; and there is now reason for assuming that cures may be found for poisoning by a number of other deadly range plants.

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Annual Report of the Board of Control for the Fiscal Year Ending June 30, 1923

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1924

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NEVADA AGRICULTURAL EXPERIMENT STATION

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Hon. Mrs. Sophie E. Williams (1929)	Hot Creek
Hon. G. F. Talbot (1931)	Reno
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George H. Taylor	Secretary Emeritus
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F. L. Bixby, C.E.	Irrigation
(Bureau of Public Roads, Irrigation Division, U. S. D. A.)	
Geo. Hardman, M.S.	Assistant in Irrigation
Charles E. Fleming, B.S.A.	Range Management
Edward Records, V.M.D.	Veterinary Science
Lyman R. Vawter, D.V.M.	Assistant in Veterinary Science
M. R. Miller, B.S.	Chemist
Mary McGee	Secretary to Veterinary Science
Martha Ryan	Librarian and Secretary to Director

I. FINANCIAL STATEMENT

C. H. Gorman

Nevada Agricultural Experiment Station

IN ACCOUNT WITH

The United States Appropriations, 1923–1924

Items	Abstract	Hatch Fund	Adams Fund
Debit			
To balance from appropriations for 1922–1923		$0.00	$0.00
Receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1924, under Acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund)		15,000.00	15,000.00
Credit			
By salaries	1	$10,075.17	$8,154.30
By labor	2	2,306.62	2,899.08
By stationery and office supplies	3	87.95	6.00
By scientific supplies, consumable	4		437.79
By feeding-stuffs	5	72.15	1,542.68
By sundry supplies	6	173.91	225.98
By fertilizers	7		
By communication service	8	161.42	16.32
By travel expenses	9	629.24	835.19
By transportation of things	10	47.30	99.45
By publications	11		
By heat, light, water, and power	12	84.41	229.54
By furniture, furnishings, and fixtures	13	547.05	
By library	14	245.50	2.80
By scientific equipment	15	2.94	44.72
By live stock	16	241.50	338.00
By tools, machinery, and appliances	17	223.78	168.15
By buildings and land	18	101.06	
By contingent expenses	19		
By balance			
Total		$15,000.00	$15,000.00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Nevada Agricultural Experiment Station for the fiscal year ended June 30, 1924; that we have found the same well kept and classified as above; that the balance brought forward from the preceding year was $0 on the Hatch Fund and $0 on the Adams Fund; that the receipts for the year from the Treasurer of the United States were $15,000 under the Act of Congress of March 2, 1887, and $15,000 under the Act of Congress of March 16, 1906, and the corresponding disbursements $15,000 and $15,000; for all of which proper vouchers are on file and have been by us examined and found correct, leaving balances of $0 and $0.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said Acts, respectively.

(Seal) (Signed) Iven Jeffries,
Attest: C. H. Gorman, *Custodian.* *Nevada State Auditor.*

II. LIST OF PROJECTS

HATCH FUND

Irrigation:

Project 29. *Duty of Water Studies in Southern Nevada.* 1922–Continuous. Project Leader, F. L. Bixby, assisted by Mr. Geo. Hardman.

Entomology:

Project 5. *Insects Injurious to Alfalfa.* 1916–Continuous. Project Leader, S. B. Doten.

Range Management:

Project 24. *Lamb Production: Methods of Producing More and Better Lambs in Nevada Range Flocks.* 1919–Continuous. Project Leader, C. E. Fleming.

Project 26. *Feeding and Finishing Range Ewes and Lambs.* 1920–Continuous. Project Leader, C. E. Fleming.

Project 27. *Pasturage and Silage Production for Sheep.* 1920–Continuous. Project Leader, C. E. Fleming.

ADAMS FUND

Veterinary Science:

Project 16. *Hemorrhagic Disease in Cattle.* 1914–Continuous. Project Leader, Dr. Edward Records, Assisted by Dr. Lyman R. Vawter.

Range Management:

Project 22. *Poisonous Range Plants.* 1916–Continuous. Project Leader, C. E. Fleming, Assisted by M. R. Miller and Dr. Lyman R. Vawter.

III. PUBLICATIONS OF THE NEVADA AGRICULTURAL EXPERIMENT STATION, FISCAL YEAR 1923-1924

Annual Report of the Board of Control for the Fiscal Year Ending June 30, 1923. By S. B. Doten.

This report is a pamphlet of sixteen pages giving an account of the finances of the Station for the year, and presenting a list of the active projects of the Station. To these are added an account of the work done upon each project in the course of the fiscal year.

Fattening Lambs With Barley and Alfalfa. Bulletin 106, Nevada Agricultural Experiment Station. By C. E. Fleming.

This bulletin gives a very interesting summary of a long series of feeding experiments conducted by Mr. Fleming through several years upon the Station Farm near Reno. The results of these tests were carefully compared with the results obtained in the feeding of bands of several thousand sheep by professional sheepmen. As the results with the large numbers were very much the same as with the small experimental lots, the facts were finally published, for they are of vital importance to western Nevada sheep owners.

The reliability of the tests on the Station Farm was due to the fact that the sheep under trial were of uniform breeding and of the same age and general condition. Copies of this bulletin are still available for distribution, although the edition will soon be exhausted.

The Spring Rabbit Brush (Tetradymia glabrata). A Range Plant Poisonous to Sheep. By C. E. Fleming, M. R. Miller, and L. R. Vawter. The American Sheep Breeder and Wool Grower. Issues of November, 1923, and March, 1924.

The two issues contain what is virtually a reprint of Bulletin No. 104 of the Nevada Station under the same title, with four illustrations. The articles give to the readers of this journal an account of the experiments with this plant and the results of a long series of feeding tests extending through several years. The conditions under which poisoning occurs on the open range are described in detail and well illustrated with photographs; and an account is given of methods of preventing losses.

The Ear Tick of Cattle and Its Control. By Dr. Edward Records, Nevada Stockgrower, August, 1923.

This is a condensed account in popular language of the habits and life-history of this pest and of its injuries to cattle under Nevada conditions, and of methods of control. It was based largely upon reports from field veterinarians in the Nevada State Veterinary Control Service.

The Alfalfa Weevil Situation. By S. B. Doten, The Nevada Stockgrower, May, 1924.

This popular account of the habits and life history of this insect was published in response to a demand for information on the part of Nevada stockmen and farmers. A report is added upon local tests in methods of control. These methods were worked out originally in the

United States Department of Agriculture by George I. Reeves of the Federal Bureau of Entomology and the local tests were made under his general direction by representatives of the Experiment Station, the State Quarantine Office, the Washoe County Farm Bureau, and the Agricultural Extension Service.

A report covering these tests will be published in the coming fiscal year.

The History of the Nevada Agricultural Experiment Station. By S. B. Doten. Included in the History of the University of Nevada (Doten), 1874–1924.

A history of the Nevada Experiment Station was woven into the general history; for in the University of Nevada the story of the Experiment Station has been of somewhat unique importance. In Nevada the funds of the Station have been greater in comparison with those of the State University than in any other State, and they have been from the beginning almost the only research funds available. The reaction of the University upon the Station is described and the effect of the latter upon the larger organization of which it is a part. A final statement is made showing the effect of administrative conditions in the University, which in recent years have made it possible to use the funds of the Station to the utmost in the solution of important problems in Nevada agriculture.

IV. REPORT OF THE EXPERIMENT STATION LIBRARY

Department and Station publications have increased so rapidly within the past year that the Library is fast outgrowing its present quarters. Not only have new publications been received but considerable progress has been made in completing the old files. The Experiment Station Record, the Farmers' Bulletins and the files of the Bulletins of the Department of Agriculture have been completed to date and many of the Station files are now up to date.

Seventy-five volumes of reports, bulletins and circulars and other publications of the Department of Agriculture and the various Experiment Stations have been bound in this fiscal year, together with a complete set of the publications of the Nevada Station.

A number of new text books on agricultural subjects have been added to the Library. It is hoped that within the coming year a set of Bailey's Encyclopedia of Horticulture can be secured.

The rule prohibiting the loaning of publications and books to students in still in force. Loans can be made to members of the faculty and staff and students may use the Station Library as a reading-room.

Two bulletins and one annual report of the Nevada Station have been sent out during the year to the regular mailing list.

Respectfully submitted,

MARTHA R. BRUCE,

Librarian.

V. THE REPORT OF THE DIRECTOR

What is the Agricultural Experiment Station and What is its Field of Work?

There are four fields of work, distinct but closely allied, and four organizations within which the University is of service to the agriculture of the State: (1) the College of Agriculture, (2) the Agricultural Extension Service; (3) the State Veterinary Control Service with its allied commissions and offices, and (4) the Agricultural Experiment Station.

The foundation of all four lies in the fact that the sciences taught in the Universities have shown their power to assist the agricultural industry, and the scientific method of inquiry has developed and systematized a mass of facts which have important bearings on agricultural practice.

Agriculture is a complex science. To understand even in general terms what is occurring in soil and crop and in the growth of animals requires a broad and thorough training. In the College of Agriculture men are trained toward such an understanding of agriculture, and are trained in the practical application of the facts and principles they learn.

Agricultural practice is a complex and difficult art, dealing with the adaptation of methods to many uncertain conditions of soil, and crop and climate. The Agricultural Extension Service assists in this adaptation of methods to conditions by putting the farmers in touch with a great mass of fact and experience gained in other States or other countries and with the whole field of fact established by scientific inquiry.

Agriculture often requires professional scientific service for the control of special conditions; as, for example, the control of animal diseases. This fact has led to the establishment of the State Veterinary Control Service and other allied organizations. In many States similar service is given in other fields, as in official seed testing, fertilizer analyses and the like.

Agriculture is an evergrowing body of information. It is added to constantly by experimental studies of all aspects of plant and animal life and of the chemistry and physics of soils. This last field of work is in a sense the foundation of progress in all the others, because the experimental method of investigation gives new explanations of old facts and adds new ones, for class-room teaching. It gives new information to be taught outside the college by the extension workers, and is of equal service in the control and regulatory work, adding constantly new methods of control and new solutions for problems centuries old. This is the field of work of the Agricultural Experiment Station.

Evidently it is necessary to hold the Station to its own field; if for no better reason, than solely because of the fundamental importance of its work. The diversion of the time and effort of the Station workers into other channels is detrimental to the work of all the other agricultural service organizations.

Importance of Favorable Administrative Conditions in the University.

Past experience has shown most clearly the great importance of leaving the Station free to shape its own organization and to develop lines of work and special studies of importance and interest to the agriculture of the State. Effective research demands that the investigator shall be free from other duties which may hold the investigator to the campus at a time when the development of his work in the Station requires his presence elsewhere in the State.

On the other hand, it is often of equal importance to keep the man close to his laboratory on the campus for months at a time; and under these conditions it may be well-nigh fatal to his success in the experimental field to take him out into the State on some mission connected with extension work.

These considerations point clearly to the need on the part of the university administration of a clear and sympathetic understanding of the conditions which favor the work of the Station and a cordial desire for its success.

Very fortunately just such conditions have become established and are becoming traditional in the University of Nevada and have gone very far toward making recent progress in the Station possible. The smallness of the Station funds, the large number of interesting problems to be solved, and the difficulty of many of the problems all combine to make this of unusual importance. In the University of Nevada the funds of the Station have been kept distinct from any other funds and have been devoted purely to their experimental purposes. In this connection it is only fair to add a word in praise of the knowledge and skill of the University Comptroller, C. H. Gorman, in his handling of Station purchases and accounts.

The central, vitally important administrative condition for successful experiment station work has been established in the University of Nevada; for the initiative in the use of the Station funds has been left fully to the director and the members of the Station staff. This has made it possible to make small funds highly effective in the solution of problems of western agriculture.

The Agricultural Experiment Station and State Funds.

The Nevada Station has been supported almost entirely by two federal funds, the Hatch Fund and the Adams Fund, each of $15,000. The annual federal income of $30,000 has been supplemented by State funds only to the extent of about $1,000 each year. This small supplementary fund has, however, been useful out of proportion to its size; for it has made it possible to make purchases and employ labor for important purposes a little out of line with the exact wording of the federal grants.

For example, this fund has been used for the purchase of books of general information for the Station Library, for the cost of travel in the development of new Station projects, to cover the expense of preliminary studies of problems which might later become recognized Station projects and for allied purposes. It is very easy to see how important even a small supplementary fund of this character may be under certain conditions.

Still, no effort has been made to secure an increase in the State

fund for the support of the Station. The State of Nevada has a small population occupying an immense territory, a territory so great and a population so small that the cost of government is necessarily high, in spite of the high per capita wealth and habitual prosperity of the people.

Under these conditions it seems clearly evident that if the State maintains the University, pays its portion of the cost of the Extension Service, maintains the State Veterinary Control Service and its allied organizations and leaves the Station free to pursue its experiments under the federal funds unhampered with unrelated duties, then it has done all that can fairly be asked by the Station. As things stand these favorable working conditions have been fully established by the segregation of all regulatory and control work in other organizations. At one time the work of the State Hygienic Laboratory, that of the Pure Food and Drugs Laboratory, soil and water analyses and other matters belonged to the Station. Because of a conflict with the purposes of the federal acts granting the Hatch and Adams funds these relationships were broken up and all regulatory and control work passed over to other organizations.

On the other hand, however, it has been exceedingly important that in the field of animal diseases the work of the Station should remain closely connected with the official veterinary work of the State Veterinary Control Service and the State Quarantine Office. This close relationship is desirable because the whole official veterinary mechanism of a great stockgrowing State should be united under one management, in which the experimental work is done with a view to making the control work effective; while the control work throws light upon the experimental studies. For these reasons the head of the Department of Veterinary Science in the Station has for many years been the head of the Veterinary Control Service of the State. This connection will probably be maintained for years to come in a manner profitable to both organizations.

The Central Problem of Nevada Agriculture.

Nevada is a stockraising State. In the year 1923 the extent of sheep and cattle raising in Nevada in comparison with any other form of agriculture is well shown by the following figures from the United States Census:

Hay	$7,137,000
Grains	330,000
Potatoes	914,000
Cattle	13,204,000
Sheep	10,269,000

The geographical situation, the altitude, the climate, the limited water supply, and the distance from markets all combine to make the raising of range sheep and cattle the leading agricultural specialty in this State.

Ranch and range bear to each other in Nevada the same relationship as do hay meadow and pasture in other States. The range is merely pasture of low carrying capacity. On the whole it is the presence of the range which makes stockraising in Nevada possible. In the cattle country the hay meadows of the home ranch are chiefly valuable

because winter feed can be raised on these meadows for cattle and sheep which range during the summer on the wild forage plants of the mountain country.

Now the Nevada stockman does not own his range, except in small part. A form of control has been established through the actual ownership of land around springs and along streams; and this control has been of value in giving stability to the livestock industry and in preventing very excessive grazing of the ranges. Still, the situation is much akin to that of a farmer in an eastern State who does not own pasture land but does own ground on which he can cut some hay. The federal government still owns most of the range country on which Nevada stockmen must depend for feed during spring, summer and autumn.

A large part of this federally owned land, this all-important range country, is included in the United States Forest Reserves; in fact the most important summer grazing grounds are thus reserved; but are, of course, open to grazing under restrictions imposed by the Forest Service. Most of these Nevada reserves are not really forests at all in the sense of growing merchantable timber. Their sparse growth of trees and shrubs may be considered of value as a "watershed forest" for the protection of the mountain country against rapid melting of the snow and excessive run-off.

Now, within the forest reserves the natural wild plant life, grasses and low growing plants and shrubs, is holding its own in spite of continuous grazing. This is due to regulations and restrictions of the Forest Service. Outside these reserves, however, this is scarcely true except in a few locations on which private control has become fully established. On the reserves the carrying capacity of the natural pasturage is even increasing; but outside the reserves on the open public domain there is ample evidence to show that the carrying capacity is slowly but steadily falling off. It even appears probable that the very measures which protect the grazing grounds within the National Forests tend to damage the outside range by making it carry a heavier burden of grazing than ever.

Now this slow but steady decrease in the natural carrying capacity of the sheep and cattle ranges is a matter whose importance to the future of Nevada cannot be overestimated. The geography and topography of the State are of such a character that away from the railroads it is necessary to raise sheep and cattle because they can be driven to the railroad over mountain trails and they are valuable enough to repay the cost of the drive and the cost of railroad transportation to market.

There are many isolated localities in Nevada where the soil is well adapted to potatoes, onions, apples, celery or other relatively high-priced crops; but it is out of the question to market anything but cattle, sheep and wool, simply because of the difficult transportation conditions. The greatest agricultural weakness of the situation in Nevada is the lack of large local markets, and the long haul to more distant city markets.

Unfortunately there is little prospect that these conditions will change much for the better in the near future. New roads and highways are of value, and the work of the State and federal governments

will ultimately be of assistance to the farmers and stockmen. Still the old handicap of distance from markets and limited water supply will exist in Nevada for an indefinite period. These conditions limit the State for years to come to the growing of sheep and cattle with a limited development of dairying and potato growing in valleys more favorably located with reference to distant markets.

In such an agricultural situation the range lands on which the existence of the ranches must always depend mean everything to the future prosperity of the State. Mining and stockraising will be the leading industries in Nevada for an indefinite number of years to come, with mining limiting its own future constantly with the working out of each new field. In fact the most important single natural resource in Nevada is the range forage of the mountains which furrow the whole surface of the State in great parallel ranges. If even the present standard of population and prosperity is to continue then the carrying capacity of the range must be maintained; for our prosperity depends more upon the range than upon any other single resource. This is the most important economic question in the life and work of the State.

Now, how is this to be done? Is there any way in which it can be accomplished? The answers to these questions are not clear. The matter is a very complicated one, involving titles to range and water, possibly involving the recognition of grazing rights as actually belonging to the ranch lands. But banking and business, population and prosperity, are all bound up in Nevada with the carrying capacity of her ranges for sheep and cattle; and the sooner an earnest and thorough study of this whole question can be made on a basis of sound economics the better it will be for the future of the State.

It is possible that in the fairly near future the study of the economic situation in this whole matter of ranch and range may be undertaken by the Nevada Experiment Station. Still, this must depend upon very considerable additions to the present federal income of the Station and upon permission to use such additional funds for these important purposes.

CONDENSED ACCOUNT OF WORK DONE UPON STATION PROJECTS DURING THE FISCAL YEAR

Project 29. Problems of Irrigation by Artesian Wells in Southern Nevada.

F. L. Bixby and George Hardman. Hatch Fund.

The Location of This Project.

In earlier years in Nevada it was considered very probable that there would be a considerable agricultural development throughout the State based upon a water supply from artesian wells. This matter was given study by the State Engineer's Office and by other agencies; but thus far the development has been retarded by the limitations in the supply of underground water, and by soil and market conditions in portions of the State where artesian water is actually available.

It has not at any time seemed probable that alfalfa hay could be raised in any considerable quantity by this means and sold at current prices; for the cost of water from artesian wells has made it seem probable that its use would be limited to crops which can be sold at relatively high prices.

In 1922 cooperative studies of underground water conditions in Nevada were entered upon in cooperation with the Bureau of Public Roads of the United States Department of Agriculture. The most favorable location for these studies seemed to be the Las Vegas Valley in southeastern Nevada. In this valley a combination of low altitude, nearness to profitable markets, railroad facilities and other conditions favor the rapid development of an agriculture based upon crops which sell at prices high enough to repay the cost of artesian wells and pumping.

As so much depended upon the installation of the right type of apparatus for pumping and upon the proper installation of the wells in the beginning, the cooperative relationship with the engineering department of the Federal Bureau of Public Roads was particularly important and timely.

Water Mounds.

In the course of the fiscal year reported upon, studies were made of water mounds in the vicinity of Las Vegas. These mounds are characteristic features of the desert country in that region. They are in reality springs which have become buried in the drifting sands. It is easy to see how this occurs. Bushes grow up around the spring, the wind-blown sand is stopped by the brush, finally forming a mound about the spring and raising its level continually higher above the surrounding plain.

Under these conditions it appears probable that if the water mound were trenched to the original level of the spring, or if central borings were made to the same level, then the spring would be restored. Moreover, pumping might then be restored to with some prospect of increasing the flow.

Few opportunities have offered thus far for testing the matter but in the cases where a test could be made no additional flow was obtained by pumping, although the opening up of the mound did clear the spring and restore what may be considered its normal flow.

Artesian Wells and Pumping.

Evidently there must be a limit to the supply of underground water, a point where the boring of new wells will diminish the flow of the older ones. However, studies of the flow of the artesian wells in the Las Vegas Valley indicate that the development of water by this means has not yet reached its limit. For example, a well recently bored by the Union Pacific Railroad gave a flow of 325 miners inches; but it did not diminish the flow from the Las Vegas Spring located less than 300 yards distant, nor did it affect the flow of other artesian wells in the immediate vicinity. Evidently the underground water supply in the ground close to the new well must be greater than there is reason to expect.

Relation Between Underground Water and the Annual Precipitation on Nearby Mountain Ranges.

This relationship has been carefully studied as far as meager precipitation data will make it possible. It is not assumed, however, that the entire water supply beneath the Las Vegas Valley comes from the nearer mountains; for the actual sources of the water have not been fully determined.

Soil and Crop Studies.

All the work thus far outlined in connection with this project in the present report has dealt with the extent of the water supply from wells, with the cost of its development and application, with the best methods of pumping where this is necessary and the possibility of regulating and controlling its use in the hope of preventing waste. Equally important studies deal with the use of the water after it has been developed. These include methods of application to the land, the water requirements of crops in the soils and climate under study, soil types and their special water requirements, and methods of soil improvement by tillage and fertilization.

In this most interesting field of work only a beginning has been made. In the course of the fiscal year 1923 pot experiments were started. The pots themselves are of galvanized iron. In these pots typical soils of the region are under test with different fertilizers. Work of this character is of distinct value; but only as it points the way for tests on a larger scale in field plots. Cooperative tests of such plots are planned for the near future. However, if funds become available, it is probable that an effort will be made to secure control of a tract or tracts of land on which field experiments may be undertaken.

It will, of course, be necessary to guard strictly against the idea of conducting demonstrations on plots or farms to show newcomers to the region what crops may be grown. This is wholly outside the field of experimental work. All experimental plots will have no other purpose than to develop useful information as to soil and water and crop conditions in the interesting and potentially fertile region of southeastern Nevada. Clean-cut experimental work of this type, however, will be a strong force in directing the development of the region and in determining its future.

Project 5. The Problem of Insects Injurious to Alfalfa. S. B. Doten. Hatch Fund.

Through the kind cooperation of Doctor L. O. Howard, Chief of the Federal Bureau of Entomology and Mr. Geo. I. Reeves of the Alfalfa Weevil Station of that Bureau at Salt Lake, cooperative relationships were established with the federal authorities which were highly beneficial.

Tests of control measures were made upon the Experiment Station Farm in which the Station joined hands with the County Farm Bureau, the Agricultural Extension Service, and the State Quarantine Officer in testing methods and demonstrating their efficiency to local farmers. These tests were under the immediate direction of Mr. S. J. Snow of the Bureau of Entomology, whose skill and experienced judgment were of the utmost service in making the results of value.

An account of these experiments will be published at an early date in the form of an Experiment Station Bulletin. It is well to state in this report, however, that the field tests made on a commercial scale showed clearly that the weevil may readily be controlled by spraying with arsenicals at the proper time and that the cost of control is very small in comparison with the increased yields of hay.

Parasites of the Alfalfa Weevil.

Several years ago a small wasp-like insect which attacks the green-worm stage of the alfalfa weevil was introduced from Utah through the kindness of Mr. Reeves. This parasite lays its eggs in the weevil larvæ where they develop into maggots which ultimately destroy the larvæ. Very little has been said about this side of the matter because the idea makes too great a popular appeal and may lead to the neglect of very profitable and necessary spraying operations. Still, it is interesting to see that the parasite has become established throughout the portion of the Truckee Meadows infested with the weevil. We do not know how much good it will finally do; but there is every prospect, on the whole, that it will reduce the number of weevils, perhaps in favorable years even to a point where spraying may become unnecessary.

Projects 24 and 26. The Problem of Producing More and Better Lambs in Nevada Range Flocks and Feeding and Finishing Range Ewes and Lambs.
C. E. Fleming. Hatch Fund.

(1) *Use of Better Bucks.* As in previous years the tests made under this project threw great emphasis upon the importance of using better bucks than those commonly employed in Nevada flocks. In fact the results obtained were so important that they are given here in summary in advance of their later publication in detail as a station bulletin.

The facts so far obtained from this study clearly demonstrate that the earning power of many flocks on range and farm can be materially and profitably increased by the use of inexpensive pure-bred rams of superior breeding.

The results of these tests show the need of vigorous action by Nevada sheepmen in discarding poorly bred rams and ceasing to use many different grades of rams of promiscuous breeding in the same flock. The use of better bucks will lead to a material increase in wool production and to greater uniformity and higher quality in both wool and mutton.

Generally speaking the range sheepman has two pay days a year; the sale of wool during the spring months and the sale of lambs in the late summer or early fall. Any economical way by which the number of pounds of sheared wool per sheep can be increased or the shipping weight and the uniformity of the lamb crop or breeding flocks can be added to will mean greater production and a better income.

The plan of the study in this project includes comparative tests to determine the effect of rams of different breeding upon (1) the daily gains of the lambs on pasture; (2) the daily gains of the lambs in the feed lot; (3) the mature weight of the lambs from the different rams; (4) the wool clip, and (5) uniformity of growth and general conformation in the lambs.

The inferior rams used in these tests were obtained from range flocks. They would be classed as scrubs; and were not a desirable type of ram to use for lamb and wool production. They were chosen because they fairly represented a type of range ram in use today for breeding purposes in many range flocks.

The rams selected as showing superior breeding were not high priced individuals. They were just ordinary higher-grade rams, with a

definite line of selected breeding behind them. They promised to transmit to their lambs such valuable qualities as an increase in the quantity and an improvement in the quality of the fleece, together with increased body weight and desirable form.

The following results of these tests are very interesting: (1) At the age of 180 days the average weights of single lambs were as follows: (a) From the pure-bred rams, 71.75 pounds; (b) from the cross-bred rams, 67.25 pounds; (c) from the grade rams, 61.75 pounds. There was a difference in weight of ten pounds between the single lambs from pure-bred rams and those from grade rams. Between the lambs from the cross-bred rams and those from the grade rams there was an average difference of 5.50 pounds.

(2) At the average age of 180 days the weights of twin lambs were

Lamb Feeding Corrals on the Station Farm

as follows: (a) From the pure-bred rams, 66.75 pounds; (b) from the cross-bred rams, 63.25 pounds, and (c) from the grade rams, 54 pounds. There was a difference in weight of 12 pounds between the twin lambs from the pure-bred rams and those from grade rams. Between the twin lambs from the cross-bred rams and those from grade rams there was an average difference of 9.25 pounds.

These differences in the summer growth of lambs due wholly to differences in the grades of the rams become very important when they are multiplied by thousands of animals.

In the feed lot when lambs from pure-bred, cross-bred and grade rams were placed on a finishing ration the following differences were noted. All the lambs were fed in the same way and they received the same amount and same combination of forage and concentrates:

(1) In 90 days there was a difference of 6.3 pounds between the lambs from a grade Rambouillet and those from a pure-bred Corriedale. (2) In 90 days there was a difference of 5.4 pounds gain between the lambs from a grade Rambouillet and those from a pure-bred Rambouillet. (3) In 90 days there was a difference of 2.9 pounds gain between the lambs from a scrub Rambouillet and those from a crossbred Corriedale. (4) It took 74 pounds more alfalfa and 72.1 pounds more grain to produce 100 pounds of gain with the lambs from the scrub Rambouillet than it did for the lambs from the pure-bred Rambouillet.

Out of 20 lambs sired by a scrub Hampshire ram, 18 were classed as culls when they came from the pastures. They required additional feeding before they were acceptable to the packing company. Twenty-six lambs from the same pastures but sired by a pure-bred Hampshire ram were all accepted by the packer.

When high-shearing pure-bred rams were used on ordinary grade Rambouillet ewes, the increase in the wool clip in two generations amounted to 3.1 pounds per ewe.

(2) *The Feeding of Ewes Prior to and During the Lambing Period With a View to Influencing the Growth of the Lamb.* Groups of ewes of uniform weight, conformation and breeding were fed various rations for different periods. One group was fed alfalfa with a supplementary ration of corn and oats from early winter to thirty days after weaning. The ewes in a second group were fed the same ration for a period of from thirty days before weaning until thirty days after weaning. Other groups were fed sunflower silage with a small quantity of corn and oats as supplements to alfalfa; and still others were given corn silage in place of the sunflower silage. A final group were fed nothing but alfalfa hay of good quality.

Very careful records of the weights of the lambs from the various groups were kept from the time they were born until they were ready for market. At the end of the entire test all the differences in weight of the lambs due to differences in the rations fed the ewes had disappeared. When the lambs were ready for market those from the ewes fed nothing but alfalfa weighed the same quite uniformly as those from ewes which had been fed the various supplementary rations. In all the groups of lambs the weights were very similar and quite uniform. As these tests are of considerable interest they will be published later in detail in bulletin form.

Project 27. The Problem of Producing Pasturage and Silage for Sheep Under Western Nevada Conditions. C. E. Fleming. Hatch Fund.

In the late summer of 1923 silage was prepared from both corn and sunflowers but in the spring of 1924 no plantings were made of either crop for it was clear that it would be out of the question to grow silage in view of the very deficient water supply which would be available late in the summer.

Pasturage experiments in the summer of 1923 gave the same good results as in previous years, showing conclusively that a high carrying capacity in pastures of blue grass and white clover may easily be attained on farms where there is an abundant and regular supply of water. This requires care in irrigation, the regular rotation of the

pastures, and no overstocking. Of course, the sheep must be kept on dry feed in the spring until the pastures have made sufficient growth to permit their being grazed without injury.

The small size of the Station pastures and the relatively large number of sheep which have been carried on them made this test of high value as a demonstration, in addition to its experimental value.

At the end of the fiscal year, July 1, there was very evident danger of severe injury to these pastures by the coming drought, the most severe in the history of the Truckee Meadows.

Project 16. The Problem of an Unidentified Hemorrhagic Disease in Cattle. Dr. Edward Records and Dr. L. R. Vawter. Adams Fund.

Very satisfactory progress was made in the study of this disease. In the course of the fiscal year a mass of evidence was gathered which tended to show that the organism which is the actual cause of the disease has at last been discovered by Doctors Records and Vawter. This organism was found repeatedly in the heart and in other organs of cattle dead or dying from this disease.

Suitable methods were developed in the laboratory for growing this organism artifically and for testing its properties with the smaller experimental animals, rabbits and guinea pigs.

As a direct result of the final isolation of the organism which causes the disease, it was possible in the course of the year to develop a serum whose curative properties are higher than those of any other preparation of the kind thus far tested.

It now appears that the expenditures from federal funds made in the study of this disease through a long period of years have been abundantly justified and that the prolonged and patient effort of workers upon this project has been consistently and wisely directed toward a most profitable end.

For some time to come, however, the studies of the casual organism will be continued and the preparation of fully efficient sera and vaccines will be the major aim of the further work upon this project.

Project 22. The Problem of the Poisonous Plants of the Sheep and Cattle Ranges. C. E. Fleming, M. R. Miller and L. R. Vawter. Adams Fund.

Work upon this project led to important results. Studies of the tall larkspur, the western goldenrod, and other common poisonous plants were made in the hope of completing the work of previous years. The most interesting results, however, were obtained through feeding experiments made with a plant which has not hitherto been considered dangerous, the common chokecherry of the mountain canyons. As this is a matter of unusual interest to stockmen the results of the tests are published in this report in advance of their later publication in bulletin form. The following summary includes the most important conclusions reached from the experimental work done with this plant.

The Common Chokecherry as a Poisonous Plant.

(1) The leaves of this common shrub of the mountain canyons are highly poisonous from early summer until the time when they begin to turn yellow in the autumn. Early in the autumn they become far less poisonous, and when they turn yellow they cease to be dangerous.

(2) The quantity of leaves which will prove poisonous enough to

THE COMMON CHOKECHERRY
A Poisonous Plant of the Summer Range

cause sickness or death depends somewhat upon the weight of the animal; for it naturally takes more to poison a heavy animal than a light one.

(3) There is little difference between the dose which will merely make the animal sick and the quantity required to kill.

(4) The active poisonous principle in the chokecherry leaves is closely related to the deadly hydrocyanic acid, "prussic acid" and the symptoms of poisoning are similar.

(5) Animals do not become immune to this poison by eating small quantities of the chokecherry leaves daily; no tolerance is established in this way.

(6) In the course of a day an animal may eat several times the quantity of leaves required to kill without any apparent injury but if it eats the fatal quantity all at one time it will die promptly. This shows that the poison is rapidly eliminated by the animal and does not accumulate.

(7) None of the remedies generally employed for hydrocyanic acid poisoning are of any value in chokecherry poisoning and there is no hope of cure after the animal has eaten the fatal dose.

(8) Chokecherry poisoning will probaly increase if the palatable grasses and other forage plants of the range become less common because of overgrazing.

Alkali Poisoning and Poisonous Plants.

In the course of the year many interesting tests and observations were made showing the effect of alkali water upon livestock. These studies were undertaken at the request of stockmen of central and southern Nevada in regions where alkali poisoning is of importance.

At the present time the alkali studies are not a separate project because it is not yet possible to say to what extent the so-called alkali poisoning is really due to the effects of certain desert plants. A little later, however, the alkali work will constitute a separate project.

Range observations were made for several weeks in the localities where damage due to alkali is most common. Later a series of tests were made at the Experiment Station Farm near Reno with alkali water prepared by dissolving the alkaline salts from the desert country to the south. In this fiscal year these tests were only begun; but the results were of considerable interest. Moreover, they pointed the way to further work for succeeding years; and made it evident that it will be possible to distinguish the effects of alkali poisoning from poisoning due to desert plants.